EUCALYPT PLANTATIONS FOR WOOD PRODUCTION

IN

PAKISTAN

BY

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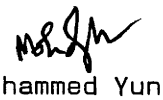
ORIGINALITY OF ESSAY

Except where specific acknowledgement is given, this essay is my own original work.



(Mohammed Yunus)

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ABSTRACT

The study deals with increasing domestic production of timber and firewood by establishing plantations of eucalypts to meet potential shortfalls in consumption in the years 1991 - 2000.

With the existing forest resource being too small in area and productivity (due to the slow growing nature of tree species and the disadvantaged location) it cannot meet potential increases in consumption, especially of timber.

Large imports of wood and wood products consume valuable foreign exchange and have resulted in many social and economic problems.

In the absence of detailed data, important variables affecting the consumption and production of wood and wood products, have been considered in presenting a possible solution within the available resources and national forest policy. These are the past 9 years trends of consumption and production of wood, economic development and 3 percent annual rate of increase in population. Potential production and shortfalls in consumption have been determined.

In the absence of detailed data, wood has been lumped into sawlog, pulplog and firewood. Potential consumption of sawlog and pulplog has been estimated for a total projected population of 80 million people and firewood for only 10 million people in the years 1991 to 2000 projected at the current annual rate of increase.

Plantations of eucalypt species of proven performance, for irrigated and dryland areas, and the appropriate techniques of establishment and harvesting have been shown capable of overcoming potential shortfalls.

Financial analysis has been carried out to find the viability of plantations. Financial analysis, based on estimates of costs and revenues with associated interest rate all expressed in real terms relative to 1980 prices and wages, indicates the viability of the plantations at a substantially higher net present worth of Rs +1270.885 million and the only possible solution in the shortest possible time of 20 years.

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CHAPTER 1

INTRODUCTION

Pakistan has been a cradle of ancient civilization since 3000 B.C. The destruction of forests to clear land for cultivation to sustain that civilization can be traced back to 1500 B.C. The recurrent invasions of Aryans from central Asia, who were a pastoral and agricultural people, started large scale clearing of land for cultivation. Those invasions forced the local people to shift to distant hills where they, likewise, had to clear forests to make a living. Until British occupation of Sind in 1843 and Punjab in 1849 forsts were still extensive. Although nominally the property of the rulers of the area there was no restriction on cutting, grazing, burning or breaking up of land for cultivation. In effect the forests were common property.

The pressure on accessible forests was increased by the construction of roads and railway tracks and the need for firewood for steam locomotives and the British army of occupation.

Political stability came with British occupation and people started large scale clearing of land to settle down in farming communities. The sub-montane forests were subject to great destruction. Habitation extended even to steeply sloping land. Timber and firewood shortages in the plains and sub-montane areas and

the concomitant erosion hazards were evident as early as 1850. Irrigated plantations in Punjab and Sind were established in the late sixties. Survey, demarcation and formal settlement started in the mid-seventies of the 19th century. By the end of the 19th century a National Forest Policy and Forest Act were promulgated and the management of forests had started.

Partition of India in 1947 left Pakistan indigent in respect of forest resources. The population of the area forming Pakistan had increased from 16.6 million in 1901 to 33.8 million in 1951. The Government recognised the problem of wood shortage and also a possible solution. As early as 1954 a National Committee on eucalypts was formed to study various species and to find more suitable species for propagation.

More than seventy percent of the population live in rural areas and use wood for all conventional purposes. The majority is consumed as fuel. Present (1980) annual domestic production of round timber (sawlog and pulplog) is 2.284 million m^3, whereas consumption is 2.64 million m^3. The shortfall is met through imports by spending scarce foreign exchange.

The position of energy consumption has greatly improved during the last two decades; natural gas proving a great boon for Pakistan. Furthermore, the provinces of Punjab, Sind and the plains areas of the North West Frontier (all major population areas) have become self-sufficient in their fuel requirements from farmlands. The Baluchis also meet their energy requirements from farmlands and locally available coal. However, about 10 million people residing in the sub-montane areas of the North West Frontier, Punjab and Azad

Kashmir are deficient in fuelwood. They meet half of their energy requiremets from farmlands. The shortfall is met by burning dung and agricultural refuse.

Pakistan has a variety of forests. They include 1) the mangrove scrub of Karachi, 2) the riverain forests of *Acacia arabica* and *Prosopis spicigera* of Sind, 3) irrigated plantations of *Dalbergia sissoo* in Punjab and Sind, 4) Olea and *A. modesta* scrub of Punjab and 5) sub-tropical and temperate coniferous forests of provinces of the North West Frontier, Baluchistan, Tribal areas and Azad Kashmir.

Coniferous forests are the main commercial forests but their productivity is very low, i.e. $0.7m^3$ ha^{-1} $year^{-1}$. Systems of management adopted by the early European foresters with long rotations and reliance on natural regeneration have been used until recently. Rotation lengths are now being reduced, although cautiously. Reforestation measures have been intensified and the roads and associated infrastructure is being developed rapidly. Until improvements in management and the infrastructure bring an increased production of wood the consumption gap will widen.

Although changing trends in management and infrastructural developments will improve wood production for the forseeable future, Pakistan cannot meet the demand for wood and wood products without increasing its plantation programme. As such, radical change and planning is required to increase domestic production of wood in the shortest possible time.

Any rationalized planning essentially requires forecasts of future consumption and production. These forecasts must be based on past and predicted future trends in consumption, the rate of economic

development, technological progress, and, above all, the number of future consumers.

In Pakistan, because of the high proportion of rural population, the rate of shift in the pattern of consumption for processed wood products cannot be expected to change greatly. Rising incomes and greater emphasis on the spread of education suggests increased use of pulp and paper. Although firewood consumption per caput has declined slowly in recent years, the change has been so slow that it can be assumed constant for the next 20 years, the proposed period of this study. The number of consumers is likely to increase rapidly. A population of about 107 million in 1990 and 144 million in 2000 A.D. is anticipated.

Assuming a 2 percent increase in per capita consumption per annum of sawnwood, industrial roundwood and panel products; a 5 percent increase in consumption of pulp and paper products; and taking per caput consumption of firewood as constant, the projected consumption for the year 1990 will be 7.361 million m^3 (roundwood) and 12.64 million m^3 (roundwood) for the year 2000.

The potential shortfall between furture consumption and production can be reduced by establishing plantations of fast growing species. The introduction of fast growing species of economic importance has thus become an integral part of forest policy and the afforestation programme in Pakistan.

Pakistan is fortunate in having long experience in irrigated and dryland afforestation. Species of the genus Eucalyptus (one of the fast growing exotics), have a history of trials in Pakistan since 1860. The gravity of the situation has compelled foresters to find

eucalypt species suitable for various edaphic and climatic conditions. Land is available. Thus, it only requires concerted and sustained effort for the establishment of eucalypt plantations to meet the challenge.

This study has arisen from a realization of the problem of the timber and firewood shortage in Pakistan and in recognition of the necessity to propose solutions in conformity with the national forest policy and the availability of resources.

Although longterm forecasting requires detailed appraisal of all components of the market for wood and wood products, the absence of pertinent data cannot justify postponing analysis of a problem which has already reached a serious situation. Therefore, starting with current consumption and assuming increases in per capita consumption per annum based on trends in economic and demographic characteristics over the past 9 years forecasts have been attempted.

Data are not available for many of the variables concerned in Pakistan and, in these cases data has been obtained from India and other countries, modified by the writer's own experience of reforestation to suit the particular conditions in Pakistan.

CHAPTER 2

FORESTRY IN THE PAKISTAN ECONOMY

Forestry involves longterm planning because of the long production cycle and requires an understanding of many factors, including economic characteristics.

2.1 PHYSIOGRAPHY, CLIMATE AND SOIL.

2.1.1 Physiography

Pakistan lies between latitude 24-37° north, longitude 61-75° east and is situated to the west of India , with borders on Afghanistan and Iran. It is a country of great physiographic contrast. The northern mountains are an extension of the Himalayas with altitudes up to 9000 metres, aligned roughly from south east to north west in the Karakorams, the Pir Panjal and the intervening ranges culminating in Nanga Parbat; thence tapering away almost at right angles into the Hindukush in Afghanistan. Smaller ranges strike southward as, for example, the Sulaiman and Kirthar Ranges. Westwards again the folds resume more latitudinal sweeps, picked out by the river valleys, the upper Zhob and Beji, the Rakshan and the Gudhari.

The eastern and south western section of the country consists of the plains of the Indus Basin which is drained by the Indus and its tributaries, the Kuram, Kabul, Jhelum and Chenab. The coastal zone, a narrow fringe bordering the Arabian Sea, includes the Indus delta and the Ran and Lasbela swamps.

2.1.2 Climate

Pakistan is a land of great climatic diversity although generally dry. The temperature extremes range between -16° to 53°C. The greater part of Pakistan is within the influence of the south west monsoon and, in this region, June is the hottest month. In regions away from the monsoonal influence as in Gilgit, Ladakh, Drosh and the greater part of Quetta and Kalat Civil Divisions, July is the hottest month. January is the coldest month all over Pakistan. Mean January temperatures in the plains of Pakistan vary from 12° to 19°C. In the high hills, the mean January temperature at Murree is 3.2°C.

There is great variation in annual precipitation over the various parts of the country. The greater part of Pakistan is arid with mean annual rainfall from less than 50 mm in the Nokundi and Kharan deserts to over 1250mm in the furthermost ranges of the Himalayas. The highest rainfall recorded is for Murree with 2525mm. The mean annual rainfall over northern Sind is about 125mm, over the sub-montane tract around Rawalpindi about 750 mm. The lower Indus plains receive rain only during the south west monsoons from July to September. The central and northern Indus plains also receive some rain during winter. The greater part of the northern

and north-western regions receive most precipitation, including snow. There is great variability of rainfall from year to year. The variability is high in areas where the greater part of the precipitation is received from the monsoons and low where most precipitation occurs in winter. Frost occurs in the northern and north-western uplands where snow has an important protective effect on the soil and ground vegetation and its gradual melting in spring is important for water supplies. Snow occasionally falls to 1000 metres but does not lie for any length of time below about 2000 metres.

Changes in the direction and velocity of the wind are usual. Hot winds are generally common in the plains during the summer months. Cold winds often blow down the larger valleys of the Himalayas.

2.1.3 Soils

Rocks in Pakistan occur in the three main groups; igneous, sedimentary and metamorphic. The hills in the north and north-east are formed of tertiary sediments; sandstone, shales and limestone. The soils derived therefrom are clays and clay loams. The sub-montane plateau and upper Indus plains have well-drained alluvial soils. In the desert areas the soils are sandy. The soils of sub-montane areas other than the sub-montane plateau are shallow and denuded in places whereas the soils of the Indus plains are quite deep.

As far as physical characteristics are concerned the alluvial soils are quite suitable for growing trees. They have a low hygroscopic co-efficient and low wilting point thus permitting greater availability of moisture for plant use. Soils in the sub-montane areas where erosion hazards have not been severe, are also quite suitable for tree growing (see Map No.1 [1]).

2.2 SOCIO-ECONOMIC CHARACTERISTICS

2.2.1 Population

Rapid growth in population is posing a serious problem for Pakistan. This growth has been out-pacing economic progress in the country and undermining the additional resources generated over the years. Thus widening the gap between timber production and consumption.

The population growth for the period 1901 to 1980 is given in the following table.

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[1] See Appendix A.

Table 2.1 POPULATION OF PAKISTAN 1901 - 1980

Year	Population in millions	Average interce nsal increase percent
1901	16.6	
1911	19.4	0.7
1921	21.1	0.9
1931	23.5	1.1
1941	28.3	1.8
1951	33.8	1.7
1961	42.9	2.4
1972	64.9	2.9
1978	78.5	
1980	80.0 (estimate)	3.0

Source: Government of Pakistan, Finance Division, Pakistan Economic Survey, 1978-79.

The density of population differs for different provinces and territories. Punjab is the most densely populated area having 183 people $/km^2$. North west Frontier Province (N.W.F.P.) has 113, Sind 100, Tribal areas 92 and Baluchistan 7. (Government of Pakistan, Statistical Year Book, 1978.) Data for Azad Kashmir are not available. More than seventy percent of the population is still rural. There is considerable shift from rural to urban areas mainly

for work. The shift to urbanization is about 15 percent, whereas urban growth itself is 26.3 percent. (Government of Pakistan; Pakistan Economic and Social Review, 1973).

The male:female ratio is 53.5:46.5. The dependent age groups (below 15 and above 65 years) form 48.7 percent of the poulation. Literacy is quite low and there is great variation in this respect in urban and rural populations and between sexes. In urban populations the literacy ratio is 41 percent (49 percent for males and 14.7 percent for females); whereas the literacy ratio in rural areas is only 14.3 percent (males 22.8 percent, females 4.7 percent).

2.2.2 Economic Growth

Economic activity, as measured by gross domestic product or some similar measure, is generally considered a major determinant of demand, not only for timber products but for other materials as well. Growth in economic activity is associated with increased demand for most timber products. In a rural economy where the greater part of economic activity is not recorded in market transactions, measurement of the level of economic production is quite difficult. However, Table 2.2 gives estimates of growth in per capita income during the last ten years.

Table 2.2 PER CAPITA INCOME GROWTH 1969-70 TO 1978-79.

(In Rupees*)

Year	At constant factor cost of 1959-60	Growth Percent	At current factor cost	Growth percent
1969-70	542	+6.9	726	+11.6
1970-71	526	-3.0	742	+2.2
1971-72	519	-1.3	748	+4.9
1972-73	542	+4.4	939	+20.7
1973-74	567	+4.6	1206	+28.4
1974-75	573	+1.1	1528	+26.7
1975-76	581	+1.4	1745	+14.2
1976-77	586	+0.9	1922	+10.1
1977-78	625	+6.7	2231	+16.1
1978-79	646	+3.4	2459	+10.2

Source: Government of Pakistan, Finance Division, Pakistan Economic Survey, 1978-79.

*Exchange rate Rs 1 equivalent to U.S. $0.10.

Average monthly consumption expenditure for rural and urban areas is Rs 237.86 and Rs 349.65 respectively (Government of Pakistan, Statistical Year Book, 1978). 68.8 percent of total expenditure in rural and 59.4 percent in urban areas is spent on food, drink clothing, footwear and personal effects, the rest on housing and miscellaneous requirements.

2.2.3 Industrial Development

Agriculture contributes 34.5 percent of recorded G.D.P. and industry 13 percent, whereas forest industries contribute 0.48 percent. The proportion from agriculture has declined during the past decade from 45 percent to its present level. 20 percent of G.D.P. is invested in Pakistan (F.A.O., 1976). Agriculture provides 53 percent and industry 13.25 percent of employment.

2.2.4 Forest Industries

The major forest products and benefits are wood, water, grazing, outdoor recreation and wildlife. The minor forest products are resin, tannin and medicinal products. The locally produced timber serves as a source of raw material and energy in the domestic economy and as a source of foreign exchange. Since Pakistan is deficient in domestic wood production, substantial quantities of wood and wood products are imported for domestic consumption and some for the manufacture of export items.

Wood in Pakistan is used for all the conventional purposes but a greater proportion is used as fuelwood. Energy from wood constitutes more than half the energy consumed. In many areas where accessible forest have been destroyed for fuelwood even dung is used as a fuel. Natural gas has proved a great boon for Pakistan; without it the energy problem could have been more serious.

2.2.5 Markets for Forest Products

There are well-established timber markets in all big cities and towns. Firewood depots are also available in most cities and towns. In areas adjoining natural forests, establishment of sale depots for firewood has always been discouraged by the forest department in an attempt to check illicit cutting from forests. There are no open markets for pulpwood which is sold either at auction or by negotiation.

There has been a rapid rise in the real price of wood products. Table 2.3 gives the index numbers for whole sale prices of timber and firewood from 1969-70 to 1977-78. As is clear from the deflated index numbers given below, since 1969-70 the real prices of timber and firewood have increased overall by 69 and 44 percent respectively, indicating that timber and firewood have become more scarce as compared to other commodities. There were, of course, price fluctuations during this period but the general trend is quite clear.

Table 2.3. DEFLATED INDEX NUMBERS FOR WHOLESALE PRICES OF TIMBER AND FIREWOOD (IN TERMS OF CONSTANT RUPEE OF 1969-70)

Year	Timber	Firewood
1969-70	100.00	100.00
1970-71	93.16	103.59
1971-72	91.22	111.18
1972-73	93.88	111.13
1973-74	84.69	130.45
1974-75	118.12	157.17
1975-76	176.71	167.57
1976-77	172.99	147.78

Source: M. Amjad, 1980. The State of Forestry in Pakistan.

2.2.6 Trade in Forest Products

Pakistan meets 25 percent of the domestic consumption of timber and timber products by imports, consitituting 2.9 percent of total imports. The imports consist mainly of paper and paper board, paper products, wood pulp, sleepers, veneer logs and plywood. The major export consists of sports goods plus some minor re-export of other timber products. The value of exports of timber products constitutes 0.7 percent of total exports. The sports goods and panel products industries have shown substantial progress during the last few years. It is hoped that if these industries can be provided with sufficient raw material they will greatly improve the balance of trade for wood products.

The values of imports and exports of wood and wood products is given for 1973-74 and 1977-78 in Tables 2.4 and 2.5.

Table 2.4 VALUE OF IMPORTS OF WOOD AND WOOD PRODUCTS

Commodity Group	Value of imports (10^3 rupees) 1973-74	1977-78
1. Fuelwood and charcoal	40	4
2. Wood in the rough or roughly squared	38573	73502
3. Wood shaped or simply worked	18659	58671
4. Veneer, plywood, board, improved or re-constituted wood and other wood worked	8875	10876
5. Wood manufactures not elsewhere specified	1368	2571
6. Pulp and waste paper	22406	28188
7. Paper and paper board	312254	324395
8. Articles made of paper pulp and paper board	71664	35312
9. Cork raw and waste	1329	1663
10. Cork manufactures	2415	5995
11. Resin	n.a.	322
12. Bamboos	n.a.	12626
13. Cane and rattan	n.a.	3467
Total	477583	557592

Source: Government of Pakistan, Pakistan Statistical Year Book, 1978.

Table 2.5 VALUE OF EXPORTS OF WOOD AND WOOD PRODUCTS

	Commodity Group	Value of exports (10^3 rupees) 1973-74	1977-78
1.	Fuelwood and charcoal	-	-
2.	Wood in the rough or roughly squared	-	15
3.	Wood shaped or simply worked	-	-
4.	Veneer, plywood, board, improved or re-constituted wood and other wood worked	43	104
5.	Wood manufacturers not elsewhere specified	2818	1273
6.	Pulp and waste paper	125	-
7.	Paper and paper board	1751	6890
8.	Articles made of paper pulp and paper board	3368	18504
9.	Cork raw and waste	-	-
10.	Cork manufactures	33	11
11.	Sports goods (wood based)	97000	96776
	Total	105138	123573

Source: Government of Pakistan, Pakistan Statistical Year Book, 1978.

2.2.7 The Social Role of Forests

Rivers in Pakistan are a great asset for multipurpose dams and irrigation systems and vital for an agricultural country having fertile alluvial land but a hot and arid climate. Forests have a considerable environmental role in protecting watersheds, conserving water resources, mitigating the risks of floods, protecting soil from erosion, providing recreational areas for densely populated urban areas, and providing habitat for wildlife. Rural communities in Pakistan derive other benefits such as forage for animals, wood for agricultural implements, mushrooms and medicinal plants, which may provide additional cash income.

Forestry activities provide employment to otherwise unemployed or underemployed people on subsistance agriculture, particularly unskilled labourers. Forests have contriuted to the establishment of many furniture, joinery and sports goods industries.

The dispersed nature of forestry activities and forest industries in Pakistan bring the benefits of regional dispersal of employment, income and economic activity.

Although Pakistan is currently a net importer of forest products, the sports goods, panel products and furniture industries are earning useful amounts of foreign exchange.

CHAPTER 3

FOREST RESOURCES AND POLICY

3.1 FOREST RESOURCES

3.1.1 Forest Area

Pakistan has 87.82 million hectares total land area, 10.3747 million hectares is designated as forest land under the control of forest departments. 6.8586 million hectares consist of state forests and 3.5161 million hectares as private and communal forests. Sixty percent of the forest area is rangeland, whereas production forests grow on 1.3316 million hectares (1.5 percent of total land area or 12.83 percent of forest area).

Twenty-eight percent of the forest area is unworkable due to steep terrain or where cutting, burning or overgrazing has removed 80 percent of the crown cover.

Area of forests as a percentage of total land area in each province and by legal category is given in Tables 3.1 and 3.2.

Table 3.1 ABSTRACT OF AREA STATISTICS, 1978

(Million hectares)

Province	Total land area	Area under the control of Forest Departments		Production forests	
		Area	Percentage of total land area	Area	Percentage of total land area
North west Frontier	10.174	1.1383	11.2	0.3679	3.6
Punjab	20.627	3.3897	16.4	0.2612	1.3
Sind	14.091	1.1251	8.0	0.3131	2.2
Baluchistan	34.718	1.0903	3.1	-	-
Northern areas	7.042	3.0486	43.3	0.2196	3.1
Azad Kashmir	1.164	0.5827	48.9	0.1698	14.3
Total	87.82	10.3747	11.8	1.3316	1.5

Source: M. Amjad, 1980. The State of Forestry in Pakistan.

Table 3.2 AREA OF FORESTS UNDER THE CONTROL OF FOREST DEPARTMENTS BY LEGAL CATEGORY

(Million hectares)

Category	N.W.F.P.	Punjab	Sind	Baluch-istan	Northern areas	Azad Kashmir	Total
State forests	0.646	3.3479	1.1251	1.0903	0.0666	0.5827	6.8586
Guzara forests*	0.4551	0.0371	-	-	-	-	0.4922
Communal forests*	0.0372	0.0017	-	-	2.982	-	3.0209
Chos Act forests*	-	0.003	-	-	-	-	0.003
Total	1.1383	3.3897	1.1251	1.0903	3.0486	0.5827	10.3747

Source: M. Amjad, 1980. The State of Forestry in Pakistan.

* Private forests

3.1.2 Forest Ownership

The land tenure systems have important effects on economic developoment. Lack of clear title places severe limitations on production decisions and investment, especially in forestry, which requires large contiguous areas over a long time.

Before the advent of British rule forests were considered the property of local rulers of the tract. In practice anyone could burn, cut, graze and break-up land for cultivation. In the last quarter of the 19th century the forest areas were surveyed, demarcated and first settled.

The ownership pattern of forests in Pakistan is mainly of the following three types:-

1. Government or State forests.
2. Cantonment and municipal forests.
3. Private forests.

Government forests are legally sub-divided into Reserved, Protected and Unclassified forests. Reserved forests are free of private rights but with the passage of time some concessions and privileges have been granted for grazing, grass cutting, and dry fuelwood collection in areas having no other resources for meeting these requirements.

Protection forests are heavily burdened with private rights (as mentioned for Reserved forests) with additional right of limited timber getting for construction of houses and other 'bona-fide' domestic uses.

The Unclassified forests are in an intermediate category going through the legal process of classification either as Reserved or Protected forests.

Cantonment and municipal forests are also divided into Reserved or Protected forests.

Privately owned forests are individually or jointly owned by family groups or by villages. Such communal 'village' forests are, however, regarded as private forests although owned by a community.

In addition to these legal categories, (according to ownership pattern) there are large areas privately owned but managed by the Government for soil conservation measures under the Chos Act of 1900.

Except for minor encroachments and the construction of roads, State forest land is non-alienable for any other Government or private use.

3.1.3 Forest Types

Because of the great variety of climatic and topographic conditions the character of forests is very diverse in Pakistan. The main forest types are as follows: (see Map No.2 [2])

1. Tropical forests - in areas in which the mean annual temperature exceeds 24°C; winter is mild and frost free. This type includes:

   (i) Swamp, tidal or coastal forests of mangrove scrub of *Avicinnia officinalis* found in the Hab River Delta of Karachi Division.

   (ii) Dry mixed deciduous forests. This sub-type is of limited occurence adjoining dry sub-tropical forests in Rawalpindi and the Murree-Kahuta foothills. In this area the mean annual temperature range is 21°-26°C but with summer temperature up to 43°C. Frost is unusual but may occur due to the proximity of hills. Annual rainfall is about 900mm. The species found are *Salmalia malabarica, Terminalia blerica, Mallotus phillipinensis, Acacia catechu, Carissa spinarum,*

[2] See Appendix B.

Cassia fistula, Dalbergia sissoo, Zizyphus nummularia, and *Dodonaea viscosa.*

(iii) Tropical thorn forests. These are open thorn forests having predominantly *Acacia* spp, with *Prosopis spicigera, Capparis* spp, *Zizyphus* spp, and *Salvadora* spp. This is the natural vegetation over the greater part of the Indus plains except the driest parts and those areas covered by annual floods. The mean annual temperature is 25°C. Rainfall varies between 125-750mm.

2. Sub-tropical forests. These forests include:-

(i) Dry sub-tropical broadleaved forests commonly known as 'Kau-phulai' forests ('Kau'-Olea, 'phulai' - *A. modesta*). This forest type is mainly found in the foot hills and lower slopes of the Himalayas, the Salt Range, Kalachitta and the Sulaiman Ranges; at its lower limits merging with tropical thorn forests; at its upper with the sub-tropical pine and temperate forests. Mean annual temperature varies between 250-900mm, winters are definite though not severe and there are occasional frosts.

(ii) Sub-tropical pine forests. Commonly known as 'chil' (*Pinus roxburghii*) forests. *P. roxburghii* may be found

in pure stands but having oaks in depressions and deciduous associates, either extending up from the dry tropical thorn type or down from the temperate forests at its upper limits. Mean annual temperature ranges between 15° and 22°C and mean annual rainfall varies between 750-1500mm. There is a definite winter with frost and some snow.

3. Montane temperate forests.

(i) Himalayan moist temperate forests. This sub-type extends along the whole length of the outer ranges of the Himalayas between the sub-tropical pine forests and the sub-alpine forests. Mean annual temperature ranges between 11-13°C. Mean annual precipitation varies between 800-1800mm, mostly received as snow fall. Winters are quite severe with regular snow falls. The chief species are *Cedrus deodara* (deodar), *Pinus wallichiana* (blue pine), *Abies pindrow* (silver fir), *Picea smithiana* (spruce) occuring pure or mixed with oaks, maple walnut, horsechestnut, and ash as broadleaved associates.

(ii) Dry temperate forests. This sub-type occupies the inner mountain ranges beyond the effective reach of the south-west monsoons. The winters are long and cold with the mean annual temperature 5-15°C. The mean

annual rainfall is less than 700mm mostly received in the form of snow. *Juniperus macropoda* open forests are also found in these forests.

4. Sub-alpine forests and alpine scrub.

(i) Sub-alpine forests - this sub-type consists of coniferous trees limited to silver fir and blue pine occuring singly or in groups. This is the top-most tree formation in the Himalayas. The mean annual temperature ranges between 10-15°C and the mean annual preciipitation varies between 75-600mm mainly as snow falls.

(ii) Alpine scrub. The scrub formations are mostly deciduous species. The climate of this sub-type is similar but more severe than the climate in the sub-alpine forests

Besides the general climatic forest types, forests in Pakistan have been classified according to vegetation type for the purposes of management. See Table 3.3.

Table 3.3 FOREST TYPES UNDER THE CONTROL OF FOREST DEPARTMENTS (1978)

(Million hectares)

	N.W.F.P.	Punjab	Sind	Baluch-istan	Northern Areas	Azad Kashmir	Total
Coniferous forests	0.8416	0.0695	-	0.1157	0.2849	0.3675	1.6792
Irrigated plantations	0.0003	0.1227	0.0720	0.0003	0.0012	-	0.1965
Riverain forests	0.0003	0.0591	0.2411	0.0021	-	-	0.3026
Scrub forests	0.1156	0.2995	0.0103	0.5980	0.6580	0.0129	1.6943
Coastal forests	-	-	0.3448	-	-	-	0.3448
Mazri lands (dwarf palm)	0.0243	-	-	-	-	-	0.0243
Linear plantations	0.0017	0.0122	-	0.0001	0.0001	-	0.0140
Range lands	0.1545	2.8267	0.4569	0.3741	2.1044	0.2023	6.1189
Total	1.1383	3.3897	1.1251	1.0903	3.0486	0.5827	10.3747

Source: M. Amjad, 1980. The State of Forestry in Pakistan.

3.1.4 Management Practices

Management of natural forests started at the end of the 19th century. Well stocked chil pine forests, commercially exploitable and growing on moderately steep slopes, are worked under a shelter wood system on rotations of 100-120 years, with exploitable diameters of 50 to 60cm. Poorly stocked forests or those growing on very steep slopes, are worked on a selection system or retained as protection forests.

The temperate coniferous forests are worked under a selection system on rotations of mostly 120 to 150 years, except Juniper which is worked on a 300 years rotation. Sub-tropical broadleaved forests are worked on a selection coppice system with a rotation of 30 years.

Radical changes have taken place in management practices over the last few years. Rotation lengths for coniferous forests have been reduced from 150 to 120 years for deodar, blue pine, fir and spruce and to 100 years for chil pine. Exploitable diameters have also been reduced from 70cm to 60cm and 50cm respectively. Thus substantial increase in hitherto low yields are expected in the near future. Instead of reliance on natural regeneration, reforestation is being carried out.

Management of the man-made forests of Punjab and Sind started as early as 1866. The irrigated plantations of Punjab are managed as a two storeyed forest. The overstorey of *D. sissoo* standards are retained for 60 years and utilized for furniture. The understorey comprises *D. sissoo* which is used for firewood and managed on a 16 year rotation and *Morus alba* which is used for sports goods and managed on a 20 year rotation.

The riverain forests are managed under a clear cutting system with aerial seeding following recession of water.

3.2 NATIONAL FOREST POLICY

The first National Forest Policy for Pakistan was issued in 1955. Under this policy commercial exploitation of timber was subordinated to the general good and envisaged an increase in area under forests by plantation establishment. To achieve this objective 10 percent of land and 10 percent of water has been set aside in new canal colonies.

The small forest area, scarcity of capital for a newly established Government and deteriorating conditions within the forests because of mounting pressure to meet timber and firewood demands for the new nation prompted a revision of forest policy in 1962. This placed major emphasis on the mangement of the forests as a commercial enterprise for the maximum production of timber and firewood. Besides general policy measures specific measures were taken and, as early as in 1954, a National Committee on eucalypts was formed to study various species and to find more suitable species for propagation in Pakistan to solve the problem of wood shortage.

Separation of East Pakistan, having a greater forest resource than West Pakistan, worsened the situation, necessitating further revision of forest policy.

The Agricultural Enquiry Committee reviewed the situation in 1975 recommending 1) nationalization of logging and marketing of timber, 2) adoption of improved logging techniques to minimize

wastage, 3) introduction of fast growing species to increase output and better management of irrigated plantations. The recommendations are being followed to date although there is a constant search for a better forest policy.

CHAPTER 4

PRODUCTION AND CONSUMPTION OF FOREST PRODUCTS

Pakistan is clearly deficient in wood and wood products. The productive forest area is small and the actual production of timber and firewood is inadequate to meet requirements. Substantial quantities of wood and wood products are imported to meet the shortfall as noted earlier.

The reserves of natural gas are adequate, being estimated as 4 x $10^{12} m^3$ compared to current production runs of only 15.3 million m^3 (Johnson, 1979). Thirty-five percent of industrial requirements are met through natural gas and almost all the big cities and towns have piped gas supplies. In areas not supplied with piped gas, bottled gas has gained tremendous use during the last few years.

Domestic production and import of wood is given in Table 4.1 for the period 1972-78.

Table 4.1 DOMESTIC PRODUCTION AND IMPORT OF WOOD (1972-78)

(Thousand m^3 roundwood)

	1972	1973	1974	1975	1976	1977	1978
Sawlog							
Production*	1273	1158	1094	1011	1156	1172	1181
Imports*	205	285	285	287	441	444	427
Total	1478	1443	1379	1298	1597	1616	1608
Pulp and Paper							
Production*	390	531	561	603	390	390	633
Imports*	201	522	489	570	510	498	96
Total	591	1053	1050	1173	900	888	729

Source: F.A.O. Year Book of Forest Products, 1978 and Pakistan Statistical Year Book, 1978.

* Roundwood equivalents.

On the basis of the 7 years trends (1972-78) of domestic production and imports, the data have been updated with 1980 as the base year for future planning. Estimated production and imports of wood for the year 1980 are given in Table 4.2.

Table 4.2 ESTIMATED PRODUCTION AND IMPORTS OF WOOD IN 1980.

(Thousand m^3 roundwood)

	Production	Imports	Total
Sawlog	1,253	427	1680
Pulp and paper products	864	96	960
Firewood	2000	-	2000

Source: M. Amjad, 1980. The State of Forestry in Pakistan.

Based on these figures per capita consumption of sawlog, pulp and paper products and firewood are given in Table 4.3.

Table 4.3 PER CAPITA CONSUMPTION OF WOOD IN 1980

(M^3 roundwood equivalents)

Sawlog	$0.021m^3$
Pulp and paper products	$0.012m^3$
Firewood*	$0.20m^3$

Source*: M. Amjad, 1980. The State of Forestry in Pakistan.

4.1 FUTURE CONSUMPTION AND PRODUCTION

4.1.1 Consumption

The consumption of wood products in various end uses is determined by many factors including population, economic activity, technology, institutional changes, relative prices of timber products, availability of substitutes and timber production.

Population is probably the significant determinant of consumption, because it is a measure of the number of consumers of such goods as houses, furniture and paper products. The distribution of population in rural and urban areas, trends in urbanization, demographic structure with respect to age and sex, literacy, style of living e.g. joint family living, rate of growth are all major components of population with respect to present and future consumption.

At 3 percent annual rate of growth the increase in population is given in Table 4.4.

Table 4.4 GROWTH IN POPULATION

(Million)

Year	Population
1980	80
1990	107
2000	144

Economic activity, as measured by gross domestic product or per capita income, is also a major determinant of the consumption of wood and wood products. In Pakistan, where more than 70 percent of people live in rural areas and a substantial part of economic activity is not documented, figures for increase in income and consumption can be misleading. Table 2.2 gives figures for the last 10 years which indicate fluctuations in growth percent from year to year, however, an average rate of growth in per capita income of about 4 percent per annum has been assumed for the period of this study. The Fifth Government Plan, however, envisages an annual real growth of 7 percent in G.D.P. at factor cost, per capita income being expected to grow by 4.2 percent per annum (Government of Pakistan, The Fifth Five Year Plan).

Technological developments, although related to the overall level of economic growth, influence the availability, relative cost, performance and saleability of timber and various competing materials.

Data are not available on the impact of technological developments on consumption. However, there is evidence of rapid change in the use of substitutes for construction and other end-uses. The relative costs of such substitutes as steel bars, pipes, and formica are low.

4.1.2 Production

The production of timber and firewood is affected by the cost of production, harvesting, transportation, availability of area, current growth, level of growing stock, management practices and relative prices.

A national resource inventory is being carried out by the Aerial Forest Inventory Division of the Pakistan Forest Institute, Peshawar. This inventory is, for the time being, limited to State forests. Regional inventories are carried out with the revision of working plans. Growth data are not available for private forests; however, a substantial quantity of timber and firewood is obtained from private forests and farmlands.

Growing stock data for State forests are given in Table 4.5.

Table 4.5 GROWING STOCK OF WORKABLE FORESTS (1976)

(Million m^3)

Coniferous forests	114.818
Irrigated plantations	2.658
Riverain forests	4.539
Scrub forests	0.325
Linear plantations	0.487
Coastal forests	0.154
Total	122.981

Source: Khanzada and Nazir, 1976. Bulletin No.9, Pakistan Forest Institute, Peshawar.

Although the workable forest area is presently quite small, improvements in infrastructure, management practices, harvesting and transportation provide firm hope of an increase in sustainable production.

Greater emphasis by the Government on farm foresty has given the incentive to farm-owners to increase current productivity and bring more areas under trees.

4.2 METHODOLOGY USED IN DETERMINATION OF FU TURE CONSUMPTION AND PRODUCTION

F.A.O. has given data of consumption of timber and timber products for Pakistan as a whole. Unfortunately, figures for the period before 1972 do not have any relevance to the present situation because of the separation of former East Pakistan which had, in fact, greater population than West Pakistan and a larger area of productive forests. However, data and assessments for Pakistan after 1972 are useful.

Per capita consumption for the period 1972-80 has been analysed to assess future consumption and production in conjunction with F.A.O. 1976 forecasts of future consumption for the period 1971-1991.

Production data derived from the F.A.O. Year Book of Forest Products 1978 and Pakistan Statistical Year Book 1978 have been updated (based on the past 7 years growth trends) for the year 1980, in order to determine consumption for the base year and for future planning.

Based on average increase in production during the past 7 years, future production for the years 1991 - 2000 has been estimated to determine the net shortfall in domestic production and consumption.

Wood and wood products have been classified into sawlog, pulpwood and firewood.

Per capita annual consumption of firewood has been kept constant when determining future demand, since it is not responsive to income increases especially in rural areas. Furthermore, consumption of firewood has been calculated for only those 10 million people who are presently short of firewood and expected to remain so for the planning period.

The trends for consumption of sawlog for the period 1972-80 indicate a decline in per capita consumption from $0.023m^3$ to $0.021m^3$. The per capita consumption of pulp and paper products for the same period indicate an increase from $0.009m^3$ to $0.012m^3$. The annual increase is only $0.0003m^3$ per capita (3.5 percent per annum).

Taking into consideration the rate of increase in population and per capita annual increase in income, future per capita consumption of sawlogs is estimated to increase at 2 percent per annum over the present level of consumption for the period of the study.

Due to the low literacy ratio, large rural population and low average income the per capita consumption of pulpwood (paper and paper products) can be expected to increase by 5 percent per annum over the present consumption from the period 1980 to 2000 A.D.

The present and future per capita consumption of sawlog, pulpwood and firewood is estimated in Table 4.6.

Table 4.6 PER CAPITA CONSUMPTION OF SAWLOG, PULPLOG AND FIREWOOD

(M^3 roundwood)

Commodity	Present per capita consumption 1980	Per capita consumption by 2000 A.D.
Sawlog	0.021	0.031
Pulpwood	0.012	0.032
Firewood	0.20	0.20

There seem to be no other alternatives to meet potential shortfalls in consumption within 10 years for firewood and pulplog and 15 years for sawlogs. The estimates of potential consumption and production and the annual shortfalls for the period beyond 1991 to 2000 are given in Table 4.7 and 4.8 for the projected population for firewood; and pulplogs and sawlogs separately.

Table 4.7 POTENTAIL CONSUMPTION AND PRODUCTION AND THE ANNUAL SHORTFALLS FOR FIREWOOD FOR THE PERIOD 1991 - 2000.

(Million M^3 roundwood)

Year	Population Millions*	Projected Consumption	Projected Production**	Potential Shortfalls
1991	13	2.60	2.35	0.25
1992	14	2.80	2.39	0.41
1993	14	2.94	2.43	0.51
1994	15	3.00	2.46	0.54
1995	15	3.10	2.50	0.60
1996	16	3.20	2.53	0.67
1997	16	3.30	2.57	0.73
1998	17	3.40	2.61	0.79
1999	17	3.50	2.65	0.85
2000	18	3.60	2.70	0.90

* Rounded figures (projected populations for low lying areas i.e. 10 million of Punjab, N.W.F.P. and Azad Kashmir).

** Annual rate of increase in production estimated at 1.5 percent (personal estimate).

Table 4.8 POTENTIAL CONSUMPTION AND PRODUCTION OF PULPLOGS AND SAWLOGS AND ANNUAL SHORTFALLS FOR THE PERIOD 1991 - 2000.

(Million M^3 roundwood)

Year	Population million*	Projected Consumption		Projected Production**		Potential Shortfall	
		Pulplog	Sawlog	Pulplog	Sawlog	Pulplog	Sawlog
1991	110	2.25	2.86	1.97	2.43	0.28	0.43
1992	114	2.45	3.03	2.13	2.55	0.32	0.48
1993	117	2.64	3.17	2.29	2.67	0.35	0.50
1994	121	2.86	3.35	2.47	2.81	0.39	0.54
1995	114	3.08	3.48	2.66	2.93	0.42	0.55
1996	128	3.34	3.68	2.87	3.09	0.47	0.59
1997	132	3.63	3.83	3.09	3.23	0.54	0.60
1998	136	3.91	4.06	3.34	3.42	0.57	0.64
1999	140	4.42	4.21	3.56	3.59	0.61	0.68
2000	144	4.58	4.46	3.88	3.76	0.70	0.70

* Rounded figures for total 80 million projected population of Pakistan.

** The projected production of pulplog and sawlog has been estimated at 7 percent and 5 percent per year respectively.

4.3 INCREASING DOMESTIC PRODUCTION

International trade has made it easier to exchange goods and services between different regions of the world. Nations having comparative advantage in terms of relatively cheaper costs of production or abundance of natural resources enjoy favourable terms of trade and balance of payments surpluses. Domestic shortfalls can be met through imports at the cost of foreign exchange.

Pakistan, as a developing nation, is spending valuable foreign exchange importing wood and wood products which could otherwise be used on the import of essential capital goods. Increasing the level of domestic production is desirable not only to save foreign exchange but to improve the balance of trade and solve many domestic problems.

In the rural sector, with subsistence agriculture, there is great disparity in distribution of income and chronic problems of unemployment or underemployment. Increasing domestic production can greatly help in employing surplus labour in foresty operations. Imports of unprocessed or semi-processed wood products have tended to concentrate wood industries in the big cities. This has adverse affects on income distribution and employment. The bulky nature of wood, and weight loss in processing, favour location of wood based industries near the forests. This brings a monetary economy to the rural areas and assists in the dispersion of industry and the formation of nuclei for other developments.

Many wood products are intermediate goods used as raw materials for other industries and have, therefore, strong forward and backward linkages.

Formerly accessible forests have been razed to the ground resulting in erosion, siltation and low productivity of agricultural lands due to the burning of dung. Thus creating political, social and economic problems.

Pakistan has the land area, security of investment, cheaper labour force, underutilized productive capacity of existing industries and those under constuction, and the management and enterpreneurial skills required to increase domestic production. This is necesary for economic, social and political reasons.

CHAPTER 5

PLANNING A PLANTATION PROGRAMME

The temperate coniferous forests, which are the main productive resource, have limitations to increased productivity due to their disadvantageous location on hilly terrain and the biological and ecological characteristics of the species growing there.

The sub-tropical scrub, tropical thorn and mangrove forests are very slow growing, adapted to rigorous climatic and edaphic conditions. Investment for improvement of these forests cannot be financially justified.

Plantations of fast growing species of proven performance, would appear to be the best alternative to increase domestic production.

5.1 GOVERNMENT POLICY

Under the Fifth Five Year Plan the Government has already embarked on the afforestation of 139,000 hectares for the period 1978-83 and the area for plantations is being increased in each plan period. Moreover the Government, through its development strategy, is firmly committed to meeting the basic requirements of the people;equitable distribution of wealth and particularly, the welfare of rural people.

5.2 THE PLANTATION PROGRAMME

To increase domestic production in sawlog, pulplog and fuelwood, plantations of proven eucalypt species for different areas are planned, based on social, economic, climatic and edaphic factors. The sawlog and pulplog plantations are to be established under irrigated conditions in the provinces of Punjab and Sind where the infrastructure and processing mills already exist. Presently the processing mills are working below capacity due to the shortage of raw material (Government of Pakistan, Fifth Five Year Plan).

Firewood plantations have been planned near the deficit areas to save transport costs and to provide rural people with employment near their homes.

5.2.1 Species Suitability

The selection of suitable species and provenances for plantation projects is especially important. The species to be selected should suit the climatic and edaphic conditions of the proposed plantation areas and should not be susceptible to insect attack and diseases. They should have desirable silvicultural characteristics and wood properties for specific end uses and should be profitable to grow. Eucalypts meet these requirements and have a very old history of planting in Pakistan.

Research and trial activities were intensified after independence in 1947. Various experts have already narrowed down the choice to the following species, which are versatile in the adaptability and end uses.

Table 5.1 SPECIES SUITABLE

Plantation areas	
Irrigated	Dryland
Eucalyptus rudis	*E. microtheca*
E. citriodora	*E. tereticornis*
E. grandis	*E. camaldulensis*
E. tereticornis	*E. sideroxylon*
E. maculata	*E. melanophloia*
E. albens	*E. grandis*
E. camaldulensis	
E. Kitsoniana	

5.2.2 Estimates of Rotation and Mean Annual Increments

Although trial plantings in Pakistan have been carried out for many years, data regarding growth and rotation lengths are not available. However, the fertile alluvial soils of the Indus plains under irrigation can give very high M.A.I.'s. There is abundant evidence of this from plantations of eucalypts grown under similar conditions in other countries. Based on the local data and the evidence from overseas plantations, the M.A.I.'s and rotation ages are estimated as follows taking lower growth figures as a precaution against over-estimating.

Table 5.2 ESTIMATED ROTATION AGE AND M.A.I.'s*

Type of plantation	Firewood		
	Rotation age	Stems ha^{-1}	M.A.I. $ha^{-1}year^{-1}$
Dryland	10 years	2000	$7m^3$
	Pulplog		
	Rotation age	Stems ha^{-1}	M.A.I. $ha^{-1}year^{-1}$
Irrigated	10 years	2000	$12m^3$
	Sawlog		
	Rotation age	Stems ha^{-1}	M.A.I. $ha^{-1}year^{-1}$
Irrigated	15 years	1111	$15m^3$

* Estimates have been derived from 'Eucalypt Palntations in India' (Lohani, 1978) and FAO 'Eucalyptus for Planting', 1976.

5.3 RESOURCES REQUIRED

5.3.1 Land Resource

The availability of suitable land, free of private rights and competing uses is important for plantation projects. Sufficient forest land suitable for plantations is available to meet the estimated shortfalls. Of the 196,500 hectares of irrigable area in Punjab and Sind, 67,600 hectares of developed and underdeveloped land are available for plantations.

The area for dryland plantations is in the low-lying sub-montane belt in the provinces of Punjab, N.W.F.P. and Azad Kashmir; adjoining chil forests at its upper altitudinal limits. This area already supports a degraded vegetation, from chil to scrub formations of broadleaved species. Productivity generally has not declined due to intensive soil conservation measures carried out under watershed management schemes.

Both irrigable and dryland areas are Government property, free of private rights.

Based on estimated M.A.I.'s and potential shortfalls between aggregate consumption and production the area required for each type of wood and plantation type is given in Table 5.3.

Table 5.3 PLANTATION AREAS REQUIRED TO MEET ESTIMATED SHORTFALL IN AVAILABILITY

(Hectares)

Year	Area required		
	Firewood*	Pulplog	Sawlog
1981	1786	2334	2623
1982	2929	2667	2667
1983	3643	2917	2845
1984	3857	3250	3023
1985	4286	3500	3112
1986	4786	3917	-
1987	5214	4500	-
1988	5643	4750	-
1989	6072	5084	-
1990	6429	5834	-
Total	44645	38753	14270

* For firewood half of the area has been taken since half of firewood requirements are met from farmlands.

A proposed provisional distribution of the proposed plantations is given in Table 5.4 determined according to consumption.

Table 5.4 DISTRIBUTION OF PLANTATIONS

(Hectares)

Province	Firewood	Pulplog	Sawlog	Total
Punjab	11000	21800	10000	42800
Sind	-	16953	4270	21223
N.W.F.P.	-	-	19400	19400
Azad Kashmir	-	-	14245	14245
Total	11000	38753	14270	97668

5.3.2 Human Resources and Management Skills

(i) Management skills

In so far as professional and managerial skills for establishment and management of irrigated and dryland plantations are concerned, the country does not require any expatriate support or special training. The indigenous professionals have a long experience of plantation forestry. Furthermore, unskilled and semi-skilled agricultural people can satisfactorily perform forestry operations. (The existing reforestation programmes have already given them adequate skills.)

(ii) Labour

An abundant labour force is available in the rural areas and many labourers will go to distant places to seek jobs. Moreover the proposed plantation areas are spread over various parts of the country so that the demand for labour is not concentrated.

(iii) Protection watchers

Plantation areas must be notified as closed to grazing in the early stages of a rotation and 'protection watchers' for every 25 hectares of dryland and 50 hectares of irrigable areas must be provided to prevent any damage by man or animals. Their pay will be debitable to plantation areas against the protection and maintance account. Since plantations are to continue in the future on a sustained yield basis, the protection watchers will eventually be upgraded to Forest Guards if they satisfy the rules currently practiced in Azad Kahsmir. The protection watchers will be released progressively due to decrease in area for protection as a result of harvesting.

(iv) Professional and managerial staff

Since the project areas are spread over various forest regions and divisions, the existing forest administration will be able to manage the additional areas within their jurisdiction as part of their normal responsibility. Furthermore, past experience of reforestation projects in Pakistan has provided proof of the greater effectiveness of territorial staff than separate project staff. Present staff (drivers and tube well operators) is insufficient therefore, an additional ten tractor drivers and 30 tube well operators have been provided for irrigated plantations.

5.3.3 Machinery and Tools

(i) Tractors and tubewells

Tractors and tubewells have a long history of use in the plains of Pakistan. Tractors have also been used on a limited scale in forestry works, not to displace labour but for greater efficiency. However, the emigration of labour overseas from some areas may warrant the use of tractors. Tractors do have a greater productive and economic efficiency in some of the hardest work such as site preparation, haulage and transport of plants in the irrigated areas. Furthermore, the extensive scale of the annual operations which must be carried out in a specific time requires the use of wheeled tractors.

Tractors are presently assembled in Pakistan. There is no problem with regard to availability of spare parts or repairs. Twenty tractors with trailers, dozer blades and other attachments have been provided for in the plan period. Ten tractors will be used from 1981-88 and another ten from 1989 to the year 2000. The difference in estimated working life is due to the harsher nature of the work during the early period.

Canal water will be available only for six months from April to September and even during this period floods and drought sometimes disrupt supply. To offset this risk, and provide adequate water during the period when canal water is not available, 30 electric tube wells have been provided for in the irrigable areas.

(ii) Tools and other equipment

At present, handsaws and axes are used in harvesting and clearing vegetation. However, the extensive and intensive nature of the initial afforestation and subsequent harvesting and coppice rotations, especially for pulpwood, demand the use of at least some chain saws as well. In dryland areas two man cross-cut saws will be used for harvesting to effect good coppice growth. Thus avoiding the maintenance and care needed for chain saws which cnanot be provided due to the scattered nature of the work.

Two hundred and fifty chain saws should be imported for use in irrigable areas. Other tools such as spades, pickaxes, sickles and handsaws will have to be purchased lcoally. For this purpose a lump sum amount has been provided in the proposed budget (see Chapter 7).

(iii) Vehicles

No vehicles have been provided for the project since administrative staff will be using vehicles which they already have.

5.3.4 Buildings

The proposed eucalypt plantations are an extension of the existing irrigated plantations of *D. sissoo*. No separate accommodation is justified for the same staff. The local labourers also return to their homes after each day's work. However, huts for 30 tube well operators and two garages cum stores are to be provided.

5.3.5 Irrigation Water

Pakistan has the largest single basin canal irrigation network in the world. The first irrigated tree plantation was established at Changa Manga in 1866 on an area of 5067 hectares (Khalid Mahmood,

1967). Since then, the area has increased to 196500 hectares. Top priority is given to the improvement and expansion of the irrigation system by the Government.

In addition to surface water Pakistan has a well developed technology for tapping ground water by tube wells.

Local data are not available for the water requirements of the recommended species of eucalypts and relatively little research seems to have been done anywhere else. However, based on a little local data and some Indian experience 0.623 cusecs or 53.8 megalitres per day per 1000 hectares has been used in subsequent calculations (Khanzada and Nazir, 1976.)

5.3.6 Financial Resources

Reforestation in natural forests started in the 1960's but establishment and financing of irrigated plantations is much older. Realizing the socio-economic impact of plantation projects, the Gevernemtn has always been liberal in providing funds from internal resources. The proposed project, having great socio-economic impact and a capability for yielding early returns, merits liberal funding. It would increase domestic production in a way not possible under any other forestry project. Under the Fifth Five Year Plan (1978-83) the Governemnt has already allocated Rupees 923 million to the forestry sector.

Allocation of additional funds to each province or state, in proportion to the quantity of work, would facilitate immediate implementation of the proposed project without putting financial constraints on current reforestation and afforestation projects.

Local data are not available on costs of various field operations. The data from India have been derived making allowances,

where possible, for differing prices and wage rates. Based on these estimates, the project would require a total of Rupees 562.563 million for the first 'seedling' rotation. If future planning is to be continued beyond the year 2000, another Rupees 130.306 million would be required for coppice rotations of pulpwood and firewood and 'seedling rotations' of sawlog (see Chapter 7).

5.3.7 Seed and Plants

Planting stock requirements have to be estimated in advance, according to the planting programme, so as to make the necessary arrangements for seed collection and raising of planting stock. Planting stock requirements depend on initial espacement, objects of management, rates of growth of species, rates of mortaility and soil fertility. The quantity of seed to be collected each year for raising the desired number of plants will depend on the number of viable seed of each specis per unit weight.

The seed of each species should be colleced according to the proportion of species desired for planting. Although species recommended have a high germination percentage it is desirable to collect more seed than is actually required. Surplus seed in one year, if properly stored can cover risks of irregular or poor seeding in other years. Although mortality in tube planting is quite low, it is desirbale to raise at least 10 percent more planting stock, cull out poorer plants and provide additional plants for 'beating-up' failures.

Local seed data for all the species recommended are not available. However, data on seed of some species in Pakistan and the rest for Australian conditions are given in Table 5.5

Table 5.5 NUMBER OF FERTILE SEEDS PER UNIT WEIGHT

Species	Number of fertile seeds per gram of seed plus chaff
1. *Eucalyptus albens*	212
2. *E. camaldulensis**	550
3. *E. citriodora**	100
4. *E. grandis*	705
5. *E. kitsoniana*	495
6. *E. maculata*	130
7. *E. melanophloia**	270
8. *E. microtheca*	212
9. *E. rudis*	600
10. *E sideroxylon*	235
11. *E. tereticornis**	373

Source: *Qadri, 1970. Description of Seeds of five *Eucalyptus* species.

Larson, 1965. Germination of eucalypt seed.

5.4 PLANTING SCHEDULE

The planting schedule is given in Table 5.6. It is based on the estimated M.A.I.'s, rotation age and resources required to increase domestic production. The sawlog plantations should be established by 1985 and firewood and pulplog plantations by 1990. Possible deviations arising from non-availability of planting stock in the first year should be adjusted within the period specified.

Table 5.6 PLANTING SCHEDULE

(Hectares year $^{-1}$)

Planting Period	Province	Commodity			
		Sawlog	Pulplog	Firewood	Total
1981	Punjab	2000	1500	1100	4600
1982		2000	1500	1100	4600
1983		2000	1500	1100	4600
1984		2000	1800	1100	4900
1985		2000	1800	1100	4900
1986		-	2000	1100	3100
1987		-	2500	1100	3600
1988		-	2700	1100	3800
1989		-	3000	1100	4100
1990		-	3500	1100	4600
	Total	10000	21800	11000	42800

Table 5.6 (Contd.)

1981	Sind	623	834	-	1457
1982		667	1167	-	1834
1983		845	1417	-	2262
1984		1023	1450	-	2473
1985		1112	1700	-	2812
1986		-	1917	-	1917
1987		-	2000	-	2000
1988		-	2050	-	2050
1989		-	2084	-	2084
1990		-	2334	-	2334
	Total	4270	16953	-	21223
1981	N.W.F.P.	-	-	4000	4000
1982		-	-	1000	1000
1983		-	-	1500	1500
1984		-	-	1500	1500
1985		-	-	1800	1800
1986		-	-	2000	2000
1987		-	-	2400	2400
1988		-	-	2700	2700
1989		-	-	3000	3000
1990		-	-	3100	3100
	Total	-	-	19400	19400

Table 5.6 (Contd.)

1981	Azad	-	-	286	286
1982	Kashmir	-	-	829	829
1983		-	-	1043	1043
1984		-	-	1257	1257
1985		-	-	1386	1386
1986		-	-	1686	1686
1987		-	-	1714	1714
1988		-	-	1843	1843
1989		-	-	1972	1972
1990		-	-	2229	2229
	Total	-	-	14245	14245

The planting schedule for the second and subsequent rotations should be based on the experience gained during the first rotation. The areas required should be determined according to productivity and consumption patterns.

The experience of other eucalypt growing countries provides abundant knowledge for the future management of coppice crops for firewood and pulpwood. Sawlogs however, have to be raised through seedling transplants.

If future plantations are to be continued the establishment schedule for the second rotation should be based on the harvesting schedule given in Table 5.7.

5.5 HARVESTING SCHEDULE

The harvesting operations will start in 1991 for fuelwood and for pulplogs and for sawlogs in 1996. Equal areas of each type of plantation will be harvested, thus releasing the area for the second rotation. Since harvesting, like establishment, is a major operation involving substantial expenditure, the harvesting schedule is given in Table 5.7 to facilitate future planning.

Table 5.7 HARVESTING SCHEDULE FIRST ROTATION

(Hectares year $^{-1}$)

Period	Province	Commodity			
		Sawlog	Pulplog	Firewood	Total
1991	Punjab	-	1500	1100	2600
1992		-	1500	1100	2600
1993		-	1500	1100	2600
1994		-	1800	1100	2900
1995		-	1800	1100	2900
1996		2000	2000	1100	5100
1997		2000	2500	1100	5600
1998		2000	2700	1100	5800
1999		2000	3000	1100	6100
2000		2000	3500	1100	6600
1991	Sind	-	834	-	834
1992		-	1167	-	1167
1993		-	1417	-	1417
1994		-	1450	-	1450
1995		-	1700	-	1700
1996		623	1917	-	2540
1997		667	2000	-	2667
1998		845	2050	-	2895
1999		1023	2084	-	3107
2000		1112	2334	-	3446

Table 5.7 (Contd.)

1991	N.W.F.P.	-	-	400	400
1992		-	-	1000	1000
1993		-	-	1500	1500
1994		-	-	1500	1500
1995		-	-	1800	1800
1996		-	-	2000	2000
1997		-	-	2400	2400
1998		-	-	2700	2700
1999		-	-	3000	3000
2000		-	-	3100	3100
1991	Azad	-	-	286	286
1992	Kashmir	-	-	829	829
1993		-	-	1043	1043
1994		-	-	1257	1257
1995		-	-	1386	.1386
1996		-	-	1686	1686
1997		-	-	1714	1714
1998		-	-	1843	1843
1999		-	-	1972	1972
2000		-	-	2229	2229

CHAPTER 6

ESTABLISHMENT TECHNIQUES

Although eucalypts have not been raised in large plantations in Pakistan, the long period over which the genus has been introduced to the country has provided research workers with the opportunity of finding nursery and plantation techniques appropriate to the various climatic and edaphic conditions of the country. A review of important aspects of nursery and plantation operations derived from local research and the experience of other eucalypt growing countries follows.

6.1 SEED

6.1.1 Seed Collection

Plantation establishment depends on the availability of good quality seed of the desired species and provenances.

Seed collection should be organised well in advance. Delays in collection and procurement can cause considerable delay in nursery and plantation schedules. The seed of the recommended species should be collected from stands of desirable characteristics. The recommended stands for seed collection for some of the species are as follows (Pryor, L.D., 1976).

Eucalyptus camaldulensis	Timber yard Changa Manga and Bund Korrai near the main road.
E. citriodora	Lahore
E. melanophloia	Chichawatni
E. microtheca	Old trees at Dera Ismail Khan.
E. tereticornis	Roadside plantation 22 kilometres from Abbottabad towards Mansehra and rest house Changa Manga.

Seed of other recommended species should be collected from 1967 plantations at Hyderabad, Khanewal, Daphar and Peshawar.

Seed should be collected in the September - October period before the opening of capsules. In collecting seed from standing trees collectors can either hang ropes over fairly large branches or stretch wires between two trees and collect the seed as it falls on tarpaulins under the branches. Smaller seed bearing branches may also be cut and carried to a protected seed extracting unit. In felled areas, inflorescences should be picked by hand and placed in closely woven or plastic bags.

Capsules open in 3 - 4 days and the branches should be thoroughly shaken when collecting the seed. Eucalypt seed contains sterile chaff with the fertile seed. The seed of recommended species should be collected on the basis of unit weight of chaff and seed combined to yield a desired number of transplants according to the planting schedule.

To overcome seed shortages it is desirable to store seed for future use. Eucalypt seed retains its viability for several years if air-dried and then stored in the dark in sealed containers at a temperature of 1 - 4°C. Gaseous disinfectants such as methylbromide should be used to protect the stored seed from insect pests.

The seed of species other than *E. camaldulensis, E. grandis, E. microtheca* and *E. rudis* is non-dormant. The seed of these four species is occasionally dormant, possibly a form of secondary dormancy induced during seed extraction or storage (Larson, 1965). Dormancy can be broken by storing in moist dark conditions for four weeks at a temperature of 1 - 4°C (F.A.O., 1976). Germinating capacity is mostly above 50 percent (Larson, 1965) and it may go above 80 percent (Lohani, 1978).

6.2 NURSERY TECHNIQUES

As early as 1924, foresters realized that eucalypt plantations cannot be established by direct seed sowing in Pakistan's conditions. Since then some research has been carried out in raising eucalypts in bottomless pots and further trials were conducted to develop new techniques for raising plants in polythene tubes.

Planting stock can be raised bare-rooted or in containers. The bare-rooted stock is cheaper but the climatic conditions limit planting to a short period in the spring. The additional costs of the tubed plants are off-set by the ability to plant during any season with sure success - a great advantage in large scale plantations.

6.2.1 Nursery Design and Management

(i) Selection of site

Proper selection of site and good lay-out and management are essential for the economical production of high quality planting stock. The location of the nursery and the topography, soil, water supply and labour availability and requirements must be considered carefully. In the sub-montane tract for dryland plantations, a nursery site should be selected on a southern aspect and centrally located, within the area to be planted. Since temporary nurseries are planned to supply tube plants for only two seasons in a particular area they do not require elaborate preparation. However, a considerable volume of suitable soil for tube filling would be required.

The nursery should be located on a slight slope for efficient water drainage. No site should be within a stream bed because of the risk of flooding, soil erosion and loss of planting stock; in the plains, water logged areas should be avoided.

(ii) Lay-out

The nursery should be compact and regular in shape to minimise wasteful walking time by workers. The beds should be laid out in regular shapes and, if possible, of uniform size to permit easier protection from sun, rain and hailstorms. Roads and paths should be properly laid out.

(iii) Clearance of site

All vegetative growth should be removed; scrub and shrubs should be cut or uprooted and burnt. Slash should be burnt outside the nursery to avoid colonization by the fungus *Rhizimia inflata* (Aldhous, 1972).

(iv) Levelling

In the plains minor levelling can be done with tractors fitted with dozer blades. Manually 'karahas' can also be used. In hilly areas terracing should be done if a sloping site is unavoidable. Absolute levelling should be avoided where this would hamper drainage.

(v) Preparation of seed beds

Seed beds 1.3 metre wide and of convenient length, should be made on levelled ground, using bricks or wooden boards as retaining walls. An insecticide such as Benzine Hexachloride (B.H.C.) should be sprayed over beds and paths as a protection against ants and other seed eating insects. Polythene sheeting 0.15mm thick and 1.3 metres wide should be spread throughout the length of the bed and over its base (Qadri, 1971). The bed should then be filled with fine river sand containing some silt and the surface of the bed should be smoothed and levelled with a straight-edged wooden board.

(vi) Sowing of seed

The seed should be sprinkled uniformly over the surface of the bed, after which fine river sand is sprinkled in a similar way to cover the seed.

(vii) Watering of seed beds

After sowing, the seed bed should be watered with a mist sprayer and should be kept moist until the pricking out of the seedlings.

The water should be sprayed with the nozzle of the sprayer pointing upwards to avoid blowing seeds out of the ground. Four waterings at 3-hourly intervals should be done.

(viii) Sowing season

Normally sowings are done in the first half of February and July. It is an advantage that sowing can be done at any season of the year. However, 27-32°C is the optimum range of temperature for germination and subsequent growth (Qadri, 1971). Optimum temperature can be maintained by providing shade in the hot season or a cover of polythene sheets in the cold season. Instead of permanent structures U-shaped M.S bars of 0.93cm diameter can be used as supports for sheets or shading material. In hill areas bent branches of poplar or mulberry can be used instead of M.S bars.

(ix) Germination

The seeds start germinating within 4 days and it is normally completed within 7-10 days. The seedlings take 4-6 weeks to attain a height of 2.5cm to 3.75cm.

(x) Pre-sowing treatment

Pre-sowing treatment may be required to break dormancy or as a protection against insect pests and fungal diseases. The species of eucalypts mentioned in sub-section 6.1.1 occasionally develop dormancy. The seeds of these species should be stored in moist dark conditions for four weeks at a temperature of 1-4°C. After this period the seed should be sown immediately to avoid reduction in germinative capacity. Dusting of seeds with B.H.C. and copper fungicides (Lohani, 1978) can help overcome insect attack or damping off during the seedling stage.

(xi) Pricking out and transplanting

Pricking out and transplanting should be done after the polythene tubes have been filled with the soil medium and arrangements for placing them in separate beds within the nursery have been made. The pricking out should be done when the seedlings have four pairs of leaves, normally after 4-6 weeks. Pricking out must be done carefully by holding the upper pair of leaves. A portion of the seed bed should be removed along with each seedling, using a thin scalpel, and taken in an earthen trough to the transplanting shed. The roots must not be exposed to direct sunlight. The roots should not curl up while transplanting in the dibble hole of the polythene container; they can be shortened with a scalpel if long, but should not be touched by hand. After putting the roots in the dibble hole up to collar height, the soil medium should be pressed firmly against the roots of each seedling along its whole length. After transplanting, the polythene containers should

be kept under shade for two days and watered with a fine rose, watering can. During this period casualities, if any, should be replaced. The containers should then be removed to prepared beds. These levelled beds, 1.3 metre wide, are covered with 0.15mm polythene sheets to check the penetration of protruding tap roots into the soil. The tublings should be allowed to remain in the beds usually for six months. Then they are ready for planting out.

The transplants remain in the nursery for hardening a few days before planting out. Two to four waterings with a sprayer or watering can are given, depending on the season.

(xii) Soil medium

After experimentation it has been found that a mixture of fine sand, silt and decomposed leaf mould or farm yard manure in the ratio of 3:3:2 by volume gives satisfactory results (Qadri, 1971).

(xiii) Polythene containers

Polythene containers of various sizes have been used but research conducted in 1970 at Peshawar showed that tubes 15cm long x 6.25cm diameter x 0.05mm thick and having 45 perforations of 0.15mm diameter are most useful (Hafeez, 1973). The containers are made locally, are black in colour and have sealed bottoms.

(xiv) Filling the containers

Although polythene tubes can be filled by hand the cost is very high. A metallic hopper devised for this purpose is much more efficient. The hopper has a big funnel 0.6 metre in diameter made of 0.96mm galvanized iron sheet supported on a wooden stand and operated by a sliding plate with a round hole which regulates the flow of soil.

(xv) Nursery protection

Hail storms and heat during summer can cause considerable damage to young seedlings. The seedlings, however, require plenty of light, so it is necessary to provide covers which can be pulled over the plants when a hailstorm or rain is expected during early growth. For partial shade reeds of "Kana" (*Saccharum munja*) should be kept available. Frosts or cold 'snaps' can be overcome by pulling polythene sheets over the transplants.

Large animals should be kept away by fences, whereas small mammals and birds should be controlled by wire gauze screens of fine netting fitted with wooden frames of standard sizes. Anthroquinone and tetramethylthiuram-disulphide 50 percent can effectively reduce damage by birds and small mammals.

Ants and termites should be controlled with carbon disulphide and D.D.T. spray. Damping-off should be controlled with soil sterilization or fungicides such as formaldehyde.

(xvi) Transportation

The utmost care is necessary in transporting plants to avoid breaking the earth ball inside the polythene tubes; otherwise high mortality will result. The plants should be thoroughly watered before moving out of the nursery.

In hilly areas where roads do not exist, plants should be moved manually in baskets or wooden crates placed side by side and kept erect. In the plains plants should be transported by tractor trailers having shelves.

The plants should be carefully stacked to avoid shaking and loosening of soil. If possible, plants should be transported in the planting season on cool, cloudy days to prevent desiccation.

Unloading plants should also be done with great care. If not urgently required in the field, the plants should be placed under shade and watered regularly until shifted to the planting site.

6.3 PLANTING TECHNIQUES

6.3.1 Selection of Site

In dryland areas, sites having the most desirable characteristics should be selected first, i.e. those sites having 1) least slope, 2) deep soils, 3) least competing vegetation, 4) adequate protection against grazing and fire, 5) least erosion hazards and 6) good accessibility to roads. In irrigated plantations in the plains new sites should adjoin existing vegetation wherever possible although this is not a critical requirement. It is not absolutely essential to find sites with all favourable qualities

since this can result in scattered patchy plantations difficult for field operations and protection. The desirable qualities which are lacking can be offset by improved site preparation.

6.3.2 Preparation of Site

(a) Dryland areas

(i) Existing vegetation and terrain

The dryland areas are found on gentle to moderately steep slopes. The existing vegetation consists of shrubs such as *Dodonaea viscosa, Acacia modesta, Punica granatum, carissa spinarum, Berberis sp, Myrsine sp, Indigofera* and *Mallotus sp*; climbers such as *Clematis, Smilax* and *Rosa* and grasses such as *Heteropogon contortus, crysopogon* and *Themeda*. In some of the areas there may be dense scrub growth, whereas at other places, due to heavy grazing and cutting, there may be sparse vegetation or even bare land.

(ii) Eradication of existing vegetation and slash disposal

Partial or complete clearance of competing vegetation is essential. The manner of eradication will depend on species, availability of labour, tools and equipment. The availability of cheap labour and the nature of the terrain preclude the use of any type of machinery. Woody plants should be cut with axes, saws and sickles, as appropriate, and left on site to dry out. Steep areas, depressions and rock outcrops unsuitable for planting should not be touched. The grasses should also be left, wherever possible, to

serve as nurse plants to protect against desiccating winds, frosts and soil erosion. However, since eucalylpts do not like competition the grasses should not be allowed to compete with, or suppress the plants.

A. modesta, D. viscosa, P. granatum, Myrsine and *Indigofera* can be harvestd by the labourers as fuelwood while thorny bushes such as *Carissa spinarum, Berberis sp* and *Rosa sp* should be used for brushwood fences. Any vegetation left unused should be collected and burnt. Care should be taken that fire should not extend to adjointing forests or private habitation.

(b) Irrigable areas in the plains

(i) Existing vegetation and terrain

The areas proposed for irrigated plantations are generally flat with only slight local undulations. The existing vegetation consists of *Prosopis spicigera, Salvadora oleoides, Capparis aphylla* and *Tamarix articulata* with *saccharum* grasses at places. The vegetation is quite sparse and does not justify mechanical clearance.

(ii) Eradication of existing vegetation and slash disposal

The existing vegetation should be cut with axes, saws and sickles. All the species can be used as fuelwood. Stumps should be dug out with spades and pick axes. Unusable material, if any, should be heaped and burnt.

6.3.3 Ground Preparation

(a) Dryland areas

As already stated these areas are gently sloping to moderately steep. The soils are eroded in most places due to overgrazing. Rainfall varies from 325mm to 1475mm, and, though sporadic, is usually torrential during July and August. Such an environment necessitates soil and water conservation techniques, to achieve best results.

Contour trenches 45cm wide x 30cm deep and 2 metres apart should be constructed. The planting pits should be made along the lower berm of these trenches to make use of ponded rain water. The trenches should have a very gentle slope towards main waterways so that only the excess storm water should drain along the trenches with least scouring. Where continuous trenches are not practicable due to terrain staggered trenches can be made.

Dryland areas proposed for fuelwood plantations in the catchments of Mangla and Terbela dams are already subject to erosion control. Erosion will be further minimised by the dense plantations of eucalypts.

(b) Irrigable areas

These areas are virtually flat with only small local irregularities. Areas reserved for plantations should be surveyed in collaboration with an Irrigation Engineer to map irrigation canals, roads and other infrastructure. The irregularities, if any, should be levelled with dozer blades fitted to wheeled tractors. The

gerneral levelling of the area should conform to the main canals and proposed distributor channels. The area should then be ploughed with tractors to a depth of 25-30cm preferably twice, the second time at right-angles to the first to secure grass control and good tilth.

6.3.4 Compartment Design and Lining Out

In irrigable areas compartments of 25 hectares should be formed, rectangular in shape, to reduce skidding distances to the extraction roads, Each compartment should be bounded by roads of convenient width so that two tractors can pass.

In dryland areas no regular shape of compartments can be maintained because of terrain variations. However, the compartment boundaries should be adjusted according to existing roads and prospective planning.

Irrespective of planting site and espacement it is worthwhile ensuring that planting lines are straight and regular to facilitate accessibility for fire contol, tending and exploitation.

Lining out should be done by means of a rope or planting chain having suitable markers at the required espacement. The planting holes or pits should be dug on intra row marks. In irrigable areas planting trenches 25cm deep, should be made with tractors.

In dryland areas, since contour trenches are already aligned at the proposed espacement of rows, the pits should be made in the lower berm of the trenches.

6.3.5 Planting Espacement

The espacement depends on the object of management, growth potential of the site and likely use of mechanical equipment in cultural and exploitation operations. Although yield per hectare increases with increasing number of stems per hectare the cost of establishlment and subsequent operations also increases per unit area. Initial spacing would also depend on the growth rate of species selected and its competitive ability with weeds. Wider spacing encourages weed growth.

Local data for the proposed sites are not available. However, from experience in other eucalypt growing countries a spacing of 3m x 3m and 2m x 2m respectively for sawlog and pulpwood for irrigable areas and 2m x 2m for firewood production for dryland areas is recommended.

6.3.6 Planting and Blank Filling

(a) Planting season

Planting season varies with climate and species. June and July are the hottest months in the plains and sub-tropical areas. July and August are the wettest months in these areas.

As a general rule, planting should be done early in the wet season. Thus plants can make use of residual warmth in the soil in cold regions and take advantage of the wet season in summer rainfall areas.

Planting eucalypts in dryland areas early in spring, i.e. the first half of February is desirable in that 'beating-up' or 'filling

in' can be carried out later in the same season. Plants can get established and make use of the monsoonal rains. In addition, the full growing season is utilized so that plants become tall and are more able to survive frost.

Planting in rainy or overcast weather when the soil is at least damp gives best results (Wattle Research Institute, 1972).

In irrigable areas planting can be done during any period of the year. However, spring planting still gives best results.

(b) Transplant size and type

There is no optimum size for plants. However, they should be healthy and sturdy and should not have less than 4 to 6 leaves. In India, transplants 15 to 20cm have been tried with good results. However, the plants should not be so small as to be suppressed by weeds. As a routine practice transplants 30cm to 40cm are best for handling and transport and give best results in planting out.

(c) Planting techniques

The object of planting is to obtain a forest of desired species at a pre-determined spacing, in the shortest posssible period and at a reasonable cost. The proper selection of tools and techniques increases the rate of survival and reduces cost.

The distribution of plants should be properly organised. Tubed plants should be placed alongside the pits or trenches at marked spacing or should be carried in crates by the planters themselves.

The tubed plant should be watered before rupturing the tube. Loose mineral soil, not duff and litter, should be placed to a depth

of 8 to 10cm at the bottom of each pit. The tube should be removed and each plant (with the ball of earth) placed upright in the centre of the pit taking care that the ball of earth does not disintegrate. The soil should be filled in around the balled roots and pressed firmly from the sides. The top of the ball of the transplant should be kept slightly below the lip of the planting hole.

The planting should be done manually in dryland and irrigated areas. The tools commonly used consist of mattocks, spades and pickaxes.

(d) Recruiting or blank-filling ('beating-up')

Some deaths usually occur after planting due to improper handling, defective site preparation, poor planting stock or adverse weather conditions. The blank-filling should be done early in the season after planting and with vigorous nursery stock of the same age as the original plants. If deaths are due to frost the planting should be done late in the season. In cases of mortality due to cutworms or grubs, insecticides such as B.H.C. should be mixed with soil in the re-planting pits.

6.3.7 Tending

(a) Fertilization

Local data are not available but fertilization trials carried out in India and other eucalypt growing countries provide evidence of increased growth. It has been established that eucalypts respond

quickly and generously to fertilization (F.A.O., 1976). The alluvial soils of the Indus plains are quite fertile but, to get better results, 150 grams per plant of 3:2:1 N.P.K. fertilizer should be applied one month after planting. The same fertilizer should also be applied in dryland areas to get higher yields.

The fertilizer should be spread 15 to 30cm away from the plants but in the same pit circle. Fertilizer tablets bonded with urea-farmaldehyde resin have also proved successful in stimulating growth when pressed into the sidewalls of the planting hole just prior to planting at a depth of 5 to 8cm (Wattle Research Institute, 1972). The application of fertilizer in the second year or to a coppice crop has negligible effects.

More local trials are needed as regards quantities and frequency of application of fertilizer to various species and different sites.

(b) Weeding and hoeing

Eucalypts are intolerant of weed competition. In irrigated areas profuse growth of weeds takes place which not only robs the plants of water and nutrients but also clogs the irrigation channels. During the first year competiting weeds must be controlled by pulling out by hand. Weeding and hoeing should be done as a single operation. Hoeing around the plant to a radius of 30cm reduces evaporation; important in hot areas. Weeding and hoeing can also be done by inter-row ploughing or mechanical cultivating.

Weeds should be cut or removed before they seed and can be disced in to form a mulch.

In dryland areas weeding and hoeing should only be done around the plants to reduce the risk of erosion. Two to three weedings in the first year, two in the second and one in the third year are sufficient to keep the plants free of competition or suppression.

6.3.8 Watering

Watering frequency in the irrigation areas depends mainly on weather and soil conditions. Frequent irrigations are required during summer. The watering should be done through the planting trenches. The trenches should be filled with water but not permitted to overflow. As a rough guide, watering at fortnightly intervals should be done during the first year; once a month during the second year. The plantations would only need irrigation for the first two years.

Silt and weeds in the irrigation channels have to be removed regularly to ensure proper utilization of water. In dryland areas contour trenches should be repaired before the overcast weather so as to make use of whatever rainfall occurs.

6.4 PLANTATION PROTECTION

The choice of suitable species and sites are basic considerations in plantation establishment. The plantations will grow vigorously when conditions are favourable, but new plantations are liable to damage by fire, animals, insects and diseases. Measures must be taken to minimize these risks.

6.4.1 Fire Protection

Under existing Forest Law inhabitants residing within 8 kilometres of a forest boundary must extinguish or assist in extinguishing fires. However, it is important to minimize the chances of fire spreading to larger areas.

Each plantation compartment should have clear strips up to 8 metres wide as fire lines. The fires usually occur during the hot dry months of May and June. The fire lines and any roads and paths passing through plantations should be kept clean during the fire season. In dryland areas the slash, if any is left, should be dumped in ravines. An actual fire should be controlled by beating with branches and counterfiring. The protection watchers should be vigilant in detecting fire and should immediately contact people to help control it.

6.4.2 Protection against Climatic Agencies

Although species suited to the climatic conditions have been recommended, the possibility of damage by wind, drought, hail and frost cannot be ruled out. No serious damage by wind has been recorded in the past. In dryland areas the impact of the drought period must be reduced by conserving as much of the rain water as possible. The contour trenches and the berms of planting pits around the plants should be maintained so that maximum rainwater is stored and penetrates to the roots.

The hail and frosts cause occasional damage particularly during the first year of planting. Severely damaged plants should be replaced by healthy, vigorous plants of the same age as the original planting stock.

6.4.3 Protection against Insects and Diseases

Damage by termites has been noticed in the past. Termites can be effectively controlled by mixing Dieldrin or Aldrin 0.8 kg at 2 percent powder per cubic metre of soil at the time of planting. The insecticide can also be used with irrigation water. Apart from termites no precautionary measures are ordinarily required as no serious disease or insect problems have been encountered in the past. However, if grass hoppers and beetles are found to be causing damage, they should be controlled by spraying with B.H.C. or Dieldrin.

6.4.4 Protection against Animals

Under the Closure and Afforestation Rules plantation areas must be notified. Fencing of large areas is quite expensive and access trails for cattel should be plugged with thorny branches.

Protection watchers have proved quite effective in controlling grazing in hill areas.

Porcupine and rabbits can cause some damage in the first two years of planting and should be controlled by trapping and hunting with dogs.

6.4.5 Protection against Damage by Man

In dryland areas one protection watcher has been provided for each 25 hectares of plantation; in irrigated areas for each 50 hectares.

6.5 PLANTATION THINNING

In pulpwood and firewood rotations the object of management is the production of the greatest possible volume of wood at clear felling. No thinning is required. There are no local or Indian data which would help to define suitable thinning regimes for sawlogs. Under irrigated conditions the growth rate will be high, but any opening up of the forest by thinning will give rise to additional costs of weeding, which may be only partially offset by the retension or sale of thinnings. Generalizations from other eucalypt growing countries can be misleading. It is therefore, left to plantation managers to assess the ratio of benefits to costs for their particular circumstances.

6.6 HARVESTING

Harvesting operations in eucalypt plantations for pulpwood and fuel require special consideration because of the need to regenerate by coppicing.

Although cheap labour is available traditional equipment i.e. axe and cross-cut hand saws will give only low productivity and are not really suitable for felling eucalypts.

To ensure successful coppicing, the time of felling and the equipment and techniques used are all important.

Felling must be timed so as to avoid the risk of frost damage. In dryland areas it should be started late in winter i.e. after mid January and completed before March 15th. This will reduce the risk of frost damage and will allow coppice regrowth to start in spring; thus making use of a full growing season in the first year of the new

crop. Although felling can be done during autumn, prolonged drought and frosts can damage the epicormic buds of potential coppice regrowth.

In irrigated areas, having no risks of frosts or drought, the felling should preferably be completed before spring.

Felling equipment is of great importance. Australian and South African experience indicates the use of chain saws instead of axes as this enhances coppice regeneration.

In dryland areas two man cross-cut saws should be used for harvesting, since maintenance and repair of chain saws can present problems. In irrigation plantations, due to the intensive nature of work, chain saws should be used.

The felling direction should be controlled for ease of extraction and disposal of lops and tops. After felling, trimming should be done with a sharp axe to give a stub free bole. For cross-cutting, the trimmed trees should be marked in standard commercial lenghts as required. Fuelwood will not necessarily need marking although ease of subsequent extraction and weighing must be considered. Cross-cutting should be done with saws to minimize wastage and to ensure greater output.

In the case of sawlogs and pulplogs debarking should be done after cross-cutting. After felling, trimming and cross-cutting, lops and tops should be removed from stumps to facilitate coppice development.

6.7 COPPICE SYSTEMS

Plantation establishment through seedling planting is quite expensive, requiring elaborate nursery and plantation techniques. The coppicing ability of eucalypts gives great advantage in allowing re-establishment at low cost and most of the major eucalypt growing countries are managing plantations on coppice rotations.

Replanting should only be considered when species are to be changed or when a coppice crop does not give a remunerative yield.

Inter-planting to replace dead stumps or failed shoots should be considered, instead of replanting the entire area. The interplants should be vigorous and planted in well prepared pits. Fertilization at the time of planting and individual weeding during the first six months will even out the tempory height dominance of coppice shoots in the second year.

The coppice shoots grow from dormant buds in the ligno-tubers which are released from dormancy. The regrowth then makes use of the main root system of the parent tree. A number of shoots develop quickly from each stool after felling because of the established root system. Self-thinning takes place due to severe competition between shoots. A few shoots gain dominance over the weaker ones which get detached or pushed outwards from the stools.

Stool height has a marked effect on the yield of the parent crop and on coppice regeneration. Since ligno-tubers are usually near to the root collar it is advisable to fell as near the ground as possible. A height of not more than 12cm has been found to result in good coppice with adequate shoots from South African and Australian experiments.

To have straighter and more valuable stems the number of shoots should be reduced to one or more (usually 2-3).

The single shoot should be left on the windward side; if more than one, they should be evenly distributed and selected for greatest diameter and best form. The selection or reduction of shoots should be made at a time when shoots have demonstrated dominance and windfirmness.

CHAPTER 7

COSTS AND RETURNS

Although irrigated and dryland afforestation projects are a routine feature of forestry, either for protective or productive purposes, the proposed project is significant as it requires large investments and deals with a single genus - *Eucalyptus*. Costs and returns must be estimated to enable the profitability of the project to be gauged in order to avoid misallocation of scarce resources.

Local data are not available for plantations of eucalypts. The values for costs and returns have been derived from Indian and other data and estimates made from the writer's own experience of reforestation projects. However, only the financial costs and revenues will be estimated. Social costs and benefits and social cost-benefit analysis represent a logical further step to be based on the financial values, but extension at this stage is beyond the scope of the study. Costs and benefits are assumed to be valued at market values and include taxes and subsidies.

Costs have been identified for distinct forestry operations wherever possible. Because of differences in the costs of production and sale prices for fuelwood, sawlog and pulpwood, the data have been estimated separately.

All revenues, prices, costs and interest rates are expressed in real terms. Thus, the complications posed in attempting to estimate future trends in inflation are avoided.

7.1 COSTS

7.1.1 Land

The value of forest land in Pakistan is not determined by market forces since it is not appropriated for any private use. Even in Government uses other than timber growing, it is transferred to the particular use without valuation. However, such land does have value in alternative uses; bare or poorly stocked forest land can be used for growing eucalypts. In the absence of market values however, appraised values are taken as the price it would command in an alternative rural use. The prices of dryland and irrigable land have been assumed to be Rs 400 and Rs 800 per hectare respectively. The value of land has been assumed not to change over the years. Although the plantations are assumed to continue for an indefinite period beyond 2000AD, the value of the land at the end of the evaluation period has been imputed to be the same (in real terms) as at the beginning. (This is a simpler alternative to the conventional approach of taking the terminal value of the land as the PNW of an infinite stream of future identical rotations). The cost of land according to the planting schedule Table 5.6 is given in Table 7.1.

Table 7.1 AREA AND COST OF LAND (ACCORDING TO THE PLANTING SCHEDULE)

Year	Irrigable land		Dryland		Total cost (million Rs)
	Area(ha)	Cost (million Rs)	Area (ha)	Cost (million Rs)	
1981	2334	1.867	1786	0.714	2.581
1982	2667	2.134	2929	1.171	3.305
1983	2917	2.333	3643	1.457	3.790
1984	3250	2.600	3857	1.543	4.143
1985	3500	2.800	4286	1.714	4.514
1986	6540	5.232	4786	1.914	7.146
1987	7167	5.733	5214	2.085	7.818
1988	7595	6.076	5643	2.257	8.333
1989	8107	6.485	6072	2.428	8.913
1990	8946	7.157	6429	2.571	9.728
	53023	42.417	44645	17.854	60.271

7.1.2 Labour and Staff

Wage rates are fixed by the Government, from time to time, for an eight hour working day. All labour other than salaried staff is hired on a daily basis and paid at a uniform rate of Rs 15. Labourers are not entitled to any fringe benefits and no allowances such as sick leave or wet weather have been included.

From past experience territorial staff are more effective than project staff, and so no additional administrative staff have been included. However, 30 tube well operators and 10 tractor drivers have been included at a rate of pay of Rs 500 and Rs 700 per head per month respectively. Annual increases in pay due to increments have also been included.

A lump sum amount of Rs 30,000 per year has been included as travelling allowance for the supervisory territorial staff.

Protection watchers will be paid at Rs 300 per month, but the expenditure will form a part of the protection and maintenance account. The protection watchers will be recruited and relieved according to the planting and harvesting schedules respectively, as shown in Tables 5.6 and 5.7.

7.1.3 Machines and tools

Twenty wheeled tractors with attachments, 30 electric motors for tube wells, 250 chain saws and other tools such as pick axes, mattocks, spades etc have been included for costing at an estimated total capital value of Rs 4.6 million as given in Table 7.2.

Table 7.2 TOTAL CAPITAL VALUE OF MACHINES AND TOOLS

Machines and tools	Number	Cost Rs
Wheeled tractors with attachments*	20	2000000
Electric tubewell motors*	30	600000
Chain saws*	250	1000000
Tools**	-	1000000*

* Estimated costs

** Lump sum amount included

7.1.4 Buildings

Two garages cum stores and 30 tube well operator huts have been included for irrigable areas at an estimated cost of Rs 550000 in the year 1981. Workshops have not been provided as all Government machinery and vehicles are repaired either by Government workshops on payment or on tenders from private workshops.

7.2 DIRECT AND OVERHEAD COSTS

The costs which could be allocated specifically to the unit of production area or operation have been included in direct costs. It has not been possible to allocate operating costs of machines and tools to specific areas or operations, so these direct costs have been treated as general project-wide costs and apportioned (approximately) over time and between project operations on the basis

of the specific direct costs. Indirect or overhead costs include depreciation, repairs, travelling allowances and contingencies. Pay of tube well operators and tractor drivers has been taken for costing as a separate item as salaries. The direct costs and overhead costs have been worked out separately in the following sections.

7.2.1 Direct Costs

7.2.1.1 Cost for raising plants

The costs for raising plants in polythene tubes based on raising 100000 plants over 6 months as worked out by Qadri (1971) are updated for the present prices and wages and is given in Table 7.3.

Table 7.3 COSTS FOR RAISING PLANTS

(Rupees)

Operation	Cost Rs / 10^5 plants
Sowing in bed including preparation of seed bed and irrigation	665
Preparation of soil mixture and filling polythene tubes	843
Pricking out, transplanting in tubes shifting of tubes to beds and irrigation	4862
Purchase of material and equipment	5630
Total	12000

Total cost per plant Rs 0.12.

7.2.1.2 Costs for establishment, protection and maintenance and harvesting of plantations

The establishment and harvesting costs have been obtained from Indian data (Lohani, 1978) and updated for differences in prices and wages in Pakistan. The costs have been worked out separately for dryland and irrigable plantations on a per hectare basis as given in Table 7.4.

Table 7.4 ESTABLISHMENT AND HARVESTING COSTS OF PLANTATIONS

(Rs/ha)

Operations		Fuelwood	Pulplog	Sawlog
1. Establishment				
(i)	Survey, demarcation of compartments selection of roads or estraction paths	50	50	50
(ii)	Construction of:			
(a)	Extraction paths	200	-	-
(b)	Roads (unmetalled)	-	400	400
(c)	Fire lines	100	100	100
(iii)	Site preparation	300	500	500
(iv)	Planting including cost of plants and transportation.	550	700	600
(v)	Watering, including water charges for canal water and clearance of irrigation channels.	-	700	600
(vi)	Tending including, fertilization, weeding, hoeings and beating-up.	1000	1000	700
	Total establishment	2200	3450	2950

Table 7.4 (Contd.)

2.	Protection and maintenance			
(i)	Protection watchers	12	6	6
(ii)	Maintenance and repairs of:			
(a)	Extraction paths	30	-	-
(b)	Roads	-	60	60
(c)	Fire lines	38	25	25
	Total	80	91	91
3.	Harvesting			
(i)	Felling including cross-cutting and debarking.	500	780	1170
(ii)	Extraction including haulage to extraction paths or roads and stacking.	300	250	300
	Total	800	1030	1470

Based on these costs per hectare total yearly costs according to the planting and harvesting schedules (Tables 5.6 and 5.7) are given in Table 7.5.

Table 7.5 TOTAL YEARLY ESTABLISHMENT, PROTECTION AND MAINTENANCE AND HARVESTING COSTS OF PLANTATIONS.

(Million Rupees)

Year	Fuelwood			
	Establishment	Protection and maintenance	Harvesting	Total Costs
1981	3.929	0.143	-	4.072
1982	6.444	0.377	-	6.821
1983	8.014	0.668	-	8.682
1984	8.485	0.976	-	9.461
1985	9.429	1.318	-	10.747
1986	10.529	1.700	-	12.229
1987	11.470	2.117	-	13.587
1988	12.414	2.568	-	14.982
1989	13.358	3.053	-	16.411
1990	14.144	3.567	-	17.711
1991	6.429	3.567	1.428	11.424
1992	6.429	3.053	2.343	11.825
1993	-	2.568	2.914	5.482
1994	-	2.117	3.085	5.202
1995	-	1.700	3.428	5.128
1996	-	1.318	3.828	5.146
1997	-	0.976	4.171	5.147
1998	-	0.668	4.514	5.182
1999	-	0.377	4.857	5.234
2000	-	0.143	5.143	5.286
Total	111.074	32.974	35.711	179.759

Table 7.5 (Contd.)

Year	Pulplog			
	Establishment	Protection and maintenance	Harvesting	Total Costs
1981	8.052	0.212	-	8.264
1982	9.201	0.454	-	9.655
1983	10.063	0.719	-	10.782
1984	11.212	1.014	-	12.226
1985	12.075	1.332	-	13.407
1986	13.513	1.688	-	15.201
1987	15.525	2.097	-	17.622
1988	16.387	2.529	-	18.916
1989	17.539	2.991	-	20.530
1990	20.127	3.521	-	23.648
1991	5.834	3.521	2.404	11.759
1992	5.834	2.991	2.747	11.572
1993	-	2.529	3.004	5.533
1994	-	2.097	3.347	5.444
1995	-	1.688	3.605	5.293
1996	-	1.332	4.034	5.366
1997	-	1.014	4.635	5.649
1998	-	0.719	4.892	5.611
1999	-	0.454	5.236	5.690
2000	-	0.212	6.009	6.221
Total	145.362	33.114	39.913	218.289

Table 7.5 (Contd.)

Year	Sawlog				Grand Total all Products
	Establishment	Protection & Maintenance	Harvesting	Total Costs	
1981	7.737	0.238	-	7.975	20.311
1982	7.867	0.480	-	8.347	24.823
1983	8.392	0.7382	-	9.130	28.594
1984	8.917	1.013	-	9.930	31.617
1985	9.180	1.296	-	10.476	34.630
1986	2.178	1.296	-	3.474	30.904
1987	2.178	1.296	-	3.474	34.683
1988	-	1.296	-	1.296	35.194
1989	-	1.296	-	1.296	38.237
1990	-	1.296	-	1.296	42.655
1991	-	1.296	-	1.296	24.479
1992	-	1.296	-	1.296	24.692
1993	-	1.296	-	1.296	12.311
1994	-	1.296	-	1.296	11.942
1995	-	1.296	-	1.296	11.717
1996	-	1.296	3.855	5.151	15.663
1997	-	1.013	3.920	4.933	15.729
1998	-	0.738	4.182	4.920	15.713
1999	-	0.480	4.443	4.923	15.847
2000	-	0.238	4.574	4.812	16.319
Total	46.449	20.49	20.974	87.913	486.061

As is apparent from Table 7.5, there is great variation in direct costs incurred during different periods of planting and even amongst the three types of plantations. Most of the costs are incurred during the establishment and harvesting phases. There is some uniformity in the costs of the three types of plantations, particularly during periods of establishment and harvesting. The variation in costs over the whole period is mainly due to protection and maintenance. Within the protection and maintenance account the variation is primarily due to increasing or decreasing the number of protection watchers. For the fuelwood and pulplog plantations during the years 1991 and 1992, and for sawlogs in the years 1986 and 1987, the expenditure under establishment is on initial tending operations only.

The ratio of total direct expenditure on the pulplog and sawlog plantations (over the whole rotation) is 71:29, and so the total (project-wide) costs (for machinery, buildings tubewells and tools used in the irrigated plantations) have been allocated between sawlogs and pulpwood on this basis. Because of the variation in use of these inputs over the rotation, the timing of these costs has been assigned on the basis of the pattern of expenditure on other direct costs. Table 7.6 indicates the percentage of total direct costs occurring in each year, for each of the forest alternatives.

Table 7.6 PERCENTAGES OF COSTS TO TOTAL COSTS IN THE FIRST ROTATION INCURRED IN EACH YEAR

Year	Fuelwood	Pulplog	Sawlog
1981	2	4	9
1982	4	4	10
1983	5	5	10
1984	5	6	11
1985	6	6	12
1986	7	7	4
1987	8	8	4
1988	8	9	1
1989	9	9	1
1990	10	11	1
1991	6	5	1
1992	6	5	1
1993	3	3	1
1994	3	2	1
1995	3	2	1
1996	3	2	7
1997	3	3	7
1998	3	3	6
1999	3	3	6
2000	3	3	6
	100	100	100

7.2.1.3 Annual operating and maintenance costs for machines and tools

Tractors with attachments, chainsaws, tools and tube well motors have been included in operating and maintenance costs.Local data are not available, however, and so estimates have been made on the basis of experience in other countries.

For tractors and attachments annual operating costs for fuel and oil have been assumed to be 50 percent of the capital value and for repairs, 25 percent. For chainsaws, annual operating costs for fuel and oil have been assumed to be 200 percent of the capital value and 50 percent for repairs. For tools, annual repair costs are assumed to be 25 percent of the capital value. The annual repairs of tube well motors have been included at 15 percent of capital cost.

Based on these assumptions the annual operating and maintenance costs are given in Table 7.7.

Table 7.7 ANNUAL OPERATING AND MAINTENANCE COSTS OF MACHINES AND TOOLS

(Rupees)

		Tractors	Chainsaws	Tools	Tube well motors	Total
Annual Capital Costs		100000	50000	40000	30000	220000
Operating Costs						
(i)	Fuel and oil	50000	100000	-	-	150000
(ii)	Repairs	25000	25000	12500	4500	67000
	Total	75000	125000	12500	4500	217000

7.2.1.4 Allocation of operating and maintenance costs.

Tractors, chainsaws and tubewell motors will be used in irrigable plantations. Half of the annual repair costs for tools i.e. Rs 6250 as operating costs have been allocated to fuelwood plantations, leaving the balance of Rs 210750, attributable to irrigated plantations. Annual operating and maintenance costs have been apportioned between pulplog and sawlog plantations in the ratio of 71:29 as before. Therefore, total operating costs are allocated to plantations over the project period as shown in Table 7.8

Table 7.8 ALLOCATION OF TOTAL OPERATING AND MAINTENANCE COSTS OF MACHINES AND TOOLS

(Million Rupees)

Year	Fuelwood	Pulpwood	Sawlog	Total Costs
1981	0.002	0.119	0.109	0.230
1982	0.005	0.119	0.123	0.247
1983	0.006	0.149	0.123	0.278
1984	0.006	0.179	0.133	0.318
1985	0.007	0.179	0.146	0.332
1986	0.008	0.209	0.049	0.266
1987	0.010	0.239	0.049	0.298
1988	0.010	0.269	0.013	0.292
1989	0.011	0.269	0.013	0.293
1990	0.012	0.334	0.013	0.359
1991	0.008	0.149	0.013	0.170
1992	0.008	0.149	0.013	0.170
1993	0.004	0.090	0.013	0.107
1994	0.004	0.060	0.013	0.077
1995	0.004	0.060	0.013	0.077
1996	0.004	0.060	0.085	0.149
1997	0.004	0.090	0.085	0.179
1998	0.004	0.090	0.072	0.166
1999	0.004	0.090	0.072	0.166
2000	0.004	0.090	0.072	0.166
	0.125	2.993	1.222	4.34

7.2.2 Overhead costs

Overhead costs include depreciation, repairs of buildings, contingencies and travelling allowance.Depreciation charges have been estimated according to the straight line method, making due allowance for any scrap values which could be realized at auction. Scrap values for the calculation of depreciation have been assumed as shown in Table 7.9.

There will be greater use of tractors for the first ten years for site preparation and some levelling. The second rotation will involve coppicing but tractors will still be used for cartage of plants and for site preparation for sawlog in 1996-2000. Forestry works are certainly not harsh on the virtually flat Indus plains, so a working life of 8 years and 12 years has been estimated respectively for the periods 1981-88 and 1989-2000.

The working life for tube well motors has been assumed as 20 years and for chain saws and other tools as 2 years. The useful life of buildings has been assumed as 20 years.

Annual repairs of buildings, electricity and water charges have been included at 8 percent of capital value.Lump sum amounts have been included for contingencies and travelling allowances.

Based on these assumptions the overhead costs are estimated in Table 7.9.

Table 7.9 ANNUAL OVERHEAD COSTS

(Rupees)

	Tractors	Chainsaws	Tools	Tubewell motors	Buildings	Total
Capital value	2000000	50000	50000	600000	550000	-
Year of working life	8 and 12*	2	2	20	20	-
Scrap value	200000	5000	2500	120000	80000	-
1. Depreciation	112500† or 75000††	22500	23750	24000	23500	206250 or 168750
2. Repairs, electricity and water charges	-	-	-	-	44000	44000
3. Contingencies	-	-	-	-	-	15000
4. Travelling allowance	-	-	-	-	-	30000
	112500 or 75000	22500	23750	24000	23500	295250 or 257700

* 10 tractors of capital value Rs 1000000 and another 10 for Rs 1000000 have been included for working life of 8 and 12 years.

† Depreciation for 10 tractors for the period 1981-88.

†† Depreciation for another 10 tractors for the period 1989-2000.

7.2.2.1 Allocation of overhead costs

Due to variations in direct costs as is clear from Tables 7.5 and 7.6 the overhead costs have been allocated on the same principle to give a realistic picture. The total depreciation expenditure for tractors, although estimated separately for two different periods of working life amount to Rs 1.8 million (Rs 0.9 million for 1981-88, and Rs 0.9 million for 1989 - 2000). The total overhead costs for irrigable areas (excluding depreciation costs for tractors) are Rs 3.118 million (Rs 0.1559 million per year). An amount of Rs 11875 out of annual depreciation of tools and Rs 5000 and Rs 10000 from contingencies and travelling allowance have been separated for fuelwood plantations for the reasons already discussed. The overhead costs are again apportioned between pulplog and sawlog plantations in proportion to the percentage of direct costs i.e. 71:29 ratio. The allocation of total overhead costs is given in Table 7.10.

Table 7.10 ALLOCATION OF TOTAL OVERHEAD COSTS

(Million Rupees)

Year	Fuelwood	Pulplog	Sawlog	Total all products
1981	0.011	0.140	0.128	0.279
1982	0.022	0.140	0.143	0.305
1983	0.027	0.175	0.143	0.345
1984	0.027	0.209	0.157	0.393
1985	0.032	0.209	0.171	0.412
1986	0.038	0.244	0.058	0.340
1987	0.043	0.279	0.058	0.380
1988	0.043	0.315	0.014	0.372
1989	0.049	0.315	0.014	0.378
1990	0.054	0.384	0.014	0.452
1991	0.032	0.175	0.014	0.221
1992	0.032	0.175	0.014	0.221
1993	0.016	0.105	0.014	0.135
1994	0.016	0.069	0.014	0.099
1995	0.016	0.069	0.014	0.099
1996	0.016	0.069	0.099	0.184
1997	0.016	0.105	0.099	0.220
1998	0.016	0.105	0.086	0.207
1999	0.016	0.105	0.086	0.207
2000	0.016	0.105	0.086	0.207
Total	0.538	3.492	1.426	5.456

7.3 TOTAL COSTS

The total costs for the plantations, as estimated in the preceding tables, are grouped into main items of cost as shown in Table 7.11 and for each year of rotation for the purposes of budgeting and control.

Table 7.11 TOTAL YEARLY COSTS FOR PLANTATIONS (FIRST ROTATION)

(Million Rupees)

Year	Land	Salaries	Direct costs	Overhead costs	Grand Total
1981	2.581	0.264	20.541	0.279	23.665
1982	3.305	0.269	25.070	0.305	28.949
1983	3.790	0.275	28.872	0.345	33.282
1984	4.143	0.280	31.935	0.393	36.751
1985	4.514	0.286	34.962	0.412	40.174
1986	7.146	0.291	31.170	0.340	38.947
1987	7.818	0.296	34.981	0.380	43.475
1988	8.333	0.302	35.486	0.372	44.493
1989	8.913	0.307	38.530	0.378	48.128
1990	9.728	0.313	43.104	0.452	53.507
1991	-	0.320	24.649	0.221	25.190
1992	-	0.328	24.863	0.221	25.412
1993	-	0.336	12.418	0.135	12.889
1994	-	0.344	12.019	0.099	12.462
1995	-	0.351	11.794	0.099	12.244
1996	-	0.359	15.812	0.184	16.355
1997	-	0.367	15.908	0.220	16.495
1998	-	0.375	15.879	0.207	16.461
1999	-	0.382	16.013	0.207	16.602
2000	-	0.390	16.485	0.207	17.082
Total	60.271	6.435	490.401	5.456	562.563

7.4 COSTS FOR SECOND ROTATION PLANTATIONS

Plantations are likely to continue indefinitely beyond the year 2000, and it is not possible to predict the trend of consumption and prices for the period beyond the present study. Budget allocation for the period within this study (1991-2000) includes the establishment cost for the second rotation crop. Costs have been estimated on the same procedure and assumptions as for the first rotation. These costs do not form a part of the financial costs for the first rotation crop.

The costs for fuelwood and pulpwood coppice establishment have been derived from the Wattle Research Institute's 'Handbook on Eucalypt Growing' and related to Pakistan's conditions for prices, wages and labour outputs. Since roads, extraction paths and fire lines already exist, only protection and maintenance has been included. Overhead costs have been left to Forest Managers to allocate on the experinece of first rotation crops. The costs for sawlog production have been included as for the first rotation given in Table 7.5.

The direct costs for establishment, protection and maintenance per hectare are given in Table 7.12.

Table 7.12 COSTS FOR SECOND ROTATION COPPICE OF FUELWOOD AND PULPLOG

(Rupees)

Operations		Fuelwood	Pulplog
1. Establishment			
(i)	Slash disposal	30	30
(ii)	Reduction of coppice shoots	120	120
(iii)	Site preparation, assuming 20 percent stump mortality and stumping	100	100
(iv)	Planting including cost of plants and transportation	120	100
(v)	Watering of seedling transplants including clearance of water channels	-	120
(vi)	Tending, including fertilization of seedling transplants, weedings and hoeings	200	200
	Total Establishment	570	670
2. Protection and maintance			
(i)	Protection watchers	12	6
(ii)	Maintenance and repair of:		
(a)	Extraction paths	30	-
(b)	Roads	-	60
(c)	Fire lines	38	25
	Total protection and maintenance	80	91

Based on these cost estimates and costs for sawlog from Table 7.5, direct costs for second rotation are given in Table 7.13.

Table 7.13 YEARLY ESTABLISHMENT, PROTECTION AND MAINTENANCE COSTS SECOND ROTATION

(Million Rupees)

Year	Fuelwood	Pulplog	Sawlog	Total for all products
1991	1.161	1.775	-	2.936
1992	2.046	2.240	-	4.286
1993	2.744	2.673	-	5.417
1994	3.174	3.191	-	6.365
1995	3.761	3.677	-	7.438
1996	4.428	4.312	7.975	16.715
1997	5.088	5.112	8.347	18.547
1998	5.784	5.711	9.130	20.625
1999	6.514	6.397	9.930	22.841
2000	7.231	7.429	10.476	25.136
Total	41.931	42.517	45.858	130.306

7.5 PLANTATION REVENUES

The plantations will generate revenues in 1991-2000 from the sale of fuelwood and pulplogs and in 1996-2000 from the sale of sawlogs.

After nationalization, royalty rates were abolished and timber was sold either at auction or through negotiations.

The estimated values have been based on predicted eucalypt yields for the various types of plantations. Conservative estimates are indicated in Table 7.14 based on little local data and on the experience of other major eucalypt growing countries. Allowances for breakages and losses have been included. No thinning has been included for the reason already given in Chapter 6. The yields will be realized according to the harvesting schedule (Table 5.7).

Based on estimated rotation ages and M.A.I.'s as shown in Table 5.2, the yields are given in Table 7.14.

Table 7.14 EUCALYPT YIELDS

(Million M^3)

Year	Fuelwood	Pulplog	Sawlog
1991	0.125	0.280	-
1992	0.205	0.320	-
1993	0.255	0.350	-
1994	0.270	0.390	-
1995	0.300	0.420	-
1996	0.335	0.470	0.59
1997	0.365	0.540	0.60
1998	0.395	0.570	0.64
1999	0.425	0.610	0.680
2000	0.450	0.700	0.700

The prices that might be offered have also been estimated from the writer's personal experience, since reliable data are not available. However, these estimates are also conservative.

Since fuelwood is sold in kgs, 700Kg/m^3 has been assumed as a standard density for conversion purposes. The estimated prices on per hectare yields are given in Table 7.15.

Table 7.15 PRICES OF FUELWOOD, PULPLOGS AND SAWLOGS

Plantation	Prices Rs/m^3	Revenues Rs/ha
Fuelwood	437.5	30625
Pulplogs	1000.0	120000
Sawlogs	1200.0	270000

Based on yields of wood and prices as given in Table 7.14 and 7.15, the annual revenues from plantations are given in Table 7.16. The imputed values of land at the end of first rotation crops (as discussed under section 7.1 and according to the harvesting schedule in Table 5.7) are also included in revenues.

Table 7.16 ANNUAL REVENUES FROM PLANTATIONS

(Million Rupees)

Year	Land	Fuelwood	Pulplogs	Sawlogs	Total
1991	2.581	54.696	280.080	-	337.357
1992	3.305	89.700	320.040	-	413.045
1993	3.790	111.567	349.920	-	465.277
1994	4.143	118.120	390.000	-	512.263
1995	4.514	131.259	420.000	-	555.773
1996	7.146	146.571	470.040	708.210	1331.967
1997	7.818	159.679	540.000	720.090	1427.587
1998	8.333	172.817	570.000	768.150	1519.300
1999	8.913	185.955	610.080	816.210	1621.158
2000	9.728	196.888	700.080	840.240	1746.936

7.6 FINANCIAL VIABILITY OF PLANTATIONS

Banks in Pakistan are nationalized and there are no private capital markets. Although the interest rate on Government borrowing is typically lower, actual interest charges for private borrowing are believed to be of the order ot 12 percent. This is not a 'real' rate of interest because it incorporates some allowance for inflation. Nevertheless it has been used as the discount rate in this study because it seems a sensible value for a 'real' rate in a perfectly competitive market.

The net present worth criterion has been used because it avoids the problems associated with the cost-benefit ratio and the internal rate of return (Gittinger, 1972).

Based on these assumptions the financial analysis is given in Table 7.17, in terms of 1980 values.

Table 7.17 FINANCIAL ANALYSIS OF PLANTATIONS FIRST ROTATION

(Million Rupees)

Year	Present value per year		
	Total costs	Total revenues	Discounted Net Revenues
1981	23.665	-	-21.133
1982	28.949	-	-23.072
1983	33.282	-	-23.697
1984	36.751	-	-23.374
1985	40.174	-	-22.779
1986	38.947	-	-19.746
1987	43.475	-	-19.650
1988	44.493	-	-17.975
1989	48.128	-	-17.374
1990	53.507	-	-17.229
1991	25.190	337.357	+89.904
1992	25.412	413.045	+99.622
1993	12.889	465.277	+103.597
1994	12.462	512.263	+102.459
1995	12.244	555.773	+99.466
1996	16.355	1331.967	+214.445
1997	16.495	1427.587	+206.019
1998	16.461	1519.300	+195.369
1999	16.602	1621.158	+186.128
2000	17.082	1746.936	+179.905

The net present worth in 1980 values of the project is Rs +1270.885 million. The analysis suggests that the project seems financially viable in its present form and location, but the many assumptions necessary in this evaluation must be noted. The analysis is not intended to be definitive. It is primarily an illustration of the data required for a financial analysis and the way in which that data are used in such an analysis.

CHAPTER 8

SUMMARY

This study has arisen from a realization of the problem of the timber and firewood shortage in Pakistan and in recognition of the necessity to propose a possible solution within the available resources and in conformity with national forest policy.

The existing forest resource is too small in area and productivity. Natural forests due to their disadvantaged location and biological characteristics have limits to increasing their production. Irrigated plantations of *D. sissoo* are also slow growing and not versatile in use.

Substantial quantities of wood and wood products are being imported to meet domestic shortfalls. These imports consume valuable foreign exchange needed for capital goods and have helped create many social and economic problems.

The population of Pakistan is increasing at 3 percent per annum. This growth is out-pacing economic progress and widening the gap between available resources and consumption.

Natural forests can yield increased volumes of wood through improvements in roads and other associated infrastructure and mangement practices. But the widening gap cannot be narrowed down by the existing forest resource, at least for the period of this study.

Pakistan has had a long experience of plantation forestry. The growth potential of various eucalypt species indicates that the genus presents a solution to the problem of increasig domestic production of wood and wood products in the shortest possible time. Through research and trials many eucalypt species have already been found suitable for irrigable and dryland areas and versatile in use as firewood, sawlogs and pulpwood.

In the absence of local data for many variables and to avoid further distortions and errors, forest products have been dealt with under sawlogs, pulplogs and firewood only. However, despite the scantiness of the local data and the difficulties of making valid assumptions and derivations from the experience of other eucalypt growing countries, an attempt has been made to determine potential shortfalls and to define a possible solution by establishing eucalypt plantations in irrigable and dryland areas.

The present annual rate of increase in population, the rate of economic development, improvements in management practices and infrastructure, and the past 9 years trends in consumption and production of wood and wood products have been taken into account for estimating future shortfalls.

The consumption of sawlogs and pulplogs has been estimated for 80 million people, projected over the period 1991 - 2000 A.D. Firewood consumption has been estimated for only 10 million people, the projected populations of the low lying areas of N.W.F.P., Punjab and Azad Kashmir projected over the same period. They seem unable to meet their increased consumption from farmlands and forests for the period of this study.

The per caput consumption of sawlogs has been assumed to increase by 2 percent per annum, and of pulplogs at 5 percent per annum. Per caput consumption of firewood has been kept constant, as it is declining slowly and is not responsive to a rise in income.

Based on the estimated potential shortfalls in consumption and the final yields of wood per hectare, land has been allocated in different provinces for raising plantations. Sawlog and pulplog plantations will be raised in irrigable areas on rotation ages of 15 years and 10 years respectively. Firewood plantations will be raised in dryland areas on ten year rotations near the places of consumption.

Establishment and harvesting techniques appropriate to the country's situation, for first rotation crops through seedling transplants and second rotation coppice systems for firewood and pulplogs have been given. Thinning has not been considered because of the total lack of data on which to base yield predictions, especially for sawlogs.

Because of both the intensive and extensive nature of the work in irrigated areas and anticipating movement of labour overseas, partial tractorization has also been included in the study.

Irrigation water from canals is available for six months from April to September. 30 tube wells have been included in the estimates both to reduce the risk of water shortages due to canal breaches during April to September, and also to provide some water for irrigation when canal water is not available.

Financial analysis has been carried out to determine the financial viability of the plantations. Financial costing has been done up to felling and stacking i.e. point of sale. To avoid over-estimation, conservative estimates of yields from irrigated plantations have been made, although the fertile alluvial lands under irrigation could produce higher yields per hectare.

All estimates of revenues, costs, and the interest rate used, are expressed in real terms relative to 1980 wages and prices, thus, avoiding the complications posed in attempting to estimate future trends in inflation.

Financial analysis of the plantations indicates the viability of the project, being substantially higher at net present worth of Rs +1270.885 million, and the only possible solution to help solve wood shortages in the shortest time.

However, estimates based on assumptions and derived data must be critically examined during the process of implementation of the plantation projects to improve their accuracy for future planning.

Substantial further research is also required with respect to thinning regimes, the use of weedicides, fertilizers and water requirements.

Social analysis, as a logical step following financial analysis, should also be carried out, when accurate data are available, to find the social profitability of the plantations.

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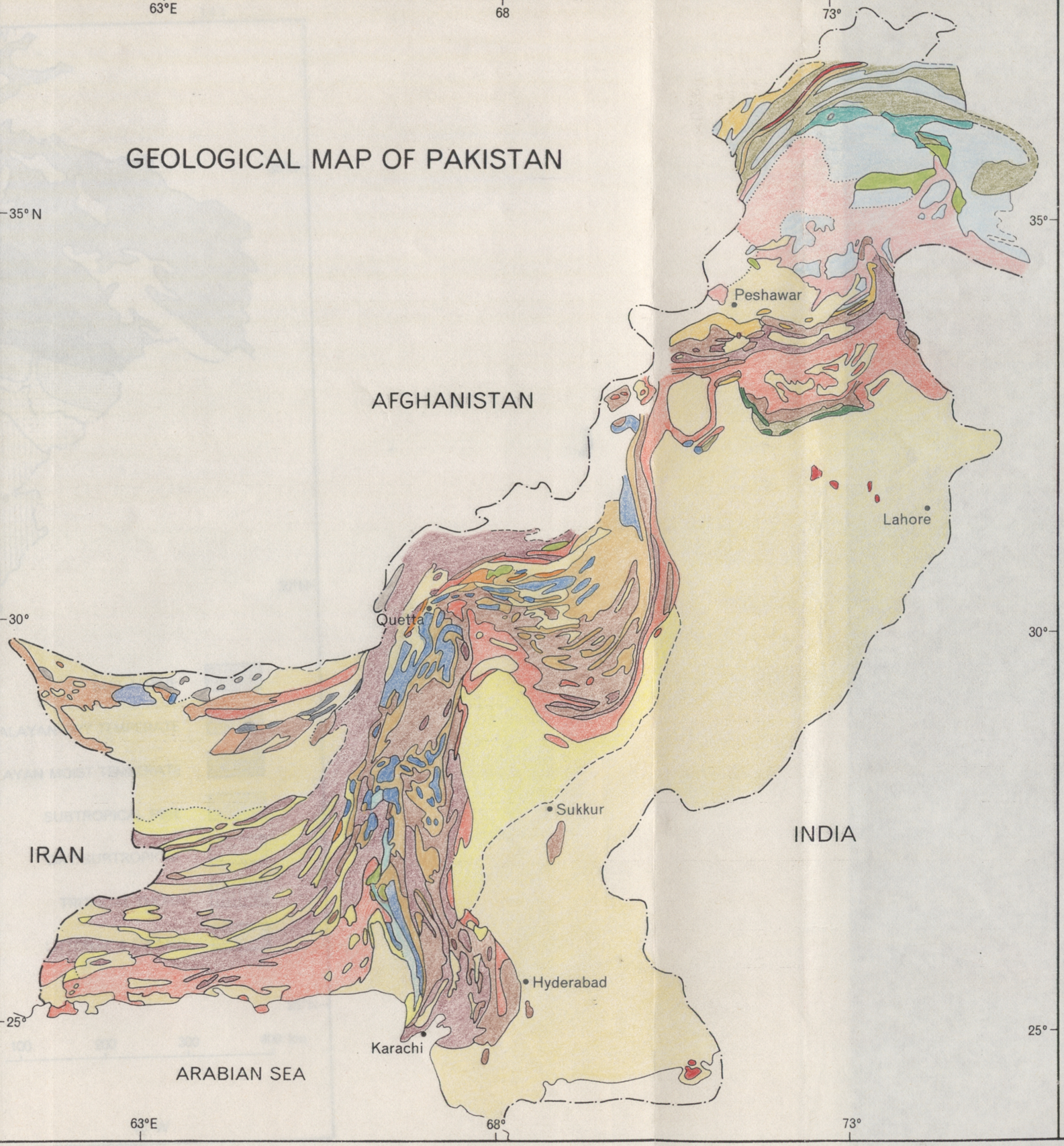
APPENDICES

GEOLOGICAL MAP OF PAKISTAN



EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY	RECENT	Alluvium, terrace deposits and sand dunes
	PLEISTOCENE	Older alluvium
TERTIARY	MIO-PLIOCENE (NEOGENE)	Makran, Manchhar and Siwalik series. (Conglomerate, sandstone, and clay)
	OLIGO-MIOCENE	Khojak shales, Nari, Gaj and Murree formations. (Limestone, sandstone and clay)
	OLIGOCENE EOCENE PALAEOCENE	Kirthar, Laki and Ranikot series. (Mainly limestone, clay and sandstone)
MESOZOIC	PALAEOCENE CRETACEOUS	Unclassified rocks of Western Kalat Division
	CRETACEOUS	Pab sandstones, Cardita beamonti beds, Hemipneustes beds, Parh limestone and Belemnite beds
	JURASSIC	Massive limestone, Oolites, Polyphemus beds, Variegated series
	TRIASSIC	Monitis beds of Baluchistan. (Limestone and shale)
	UNDIFFERENTIATED MESOZOIC	Ceratite beds, Bivalve limestones, Crinoidal-dolomitic sandstones, Triassic, Jurassic and Cretaceous of Kohat, Kalachitta, Hazara and Undifferentiated Mesozoics of Chitral. (Mainly limestone and shale)
PALAEOZOIC	PERMO-CARBONIFEROUS	Talchir boulder bed, Conularia beds, Speckled sandstone series, Productus limestone, Fusulina limestone, Darkot group
	CAMBRIAN	Saline series, Purple sandstone series, Neobolus beds, Magnesian sandstones, Salt Pseudomorph beds

IGNEOUS ROCKS

TERTIARY	UNCLASSIFIED EFFUSIVES	Upper Tertiary volcanic rocks of Baluchistan
	INTERMEDIATE and/or BASIC INTRUSIVES	Dolerite, diorite and gabbro intrusions of Chagai
	UNCLASSIFIED EFFUSIVES	Volcanics of Raskoh Range
	UNCLASSIFIED EFFUSIVES	Volcanics of Las Bela
MESOZOIC	ACID INTRUSIVES	Granite, granite-gneiss and granodiorite of Hazara, Chitral and Himalayas
	BASIC and ULTRABASIC INTRUSIVES	Dolerite, gabbro and peridotite of Himalayas Zhob and Las Bela
	UNCLASSIFIED EFFUSIVES	Greenstone complex of N.W. Himalayan Region

METAMORPHIC ROCKS

PRE-CAMBRIAN or PRE-PALAEOZOIC or MESOZOIC	UNCLASSIFIED CRYSTALLINES	Quartzite, slate, schist, gneiss and granite of Swat, Chitral and N.W. Himalayas
	UNCLASSIFIED CRYSTALLINES	Quartzite, tuff, slate and granite of Kirana hills and Tharparkar

0 100 200 300 400 km

DISTRIBUTION OF FOREST TYPES
PAKISTAN AND KASHMIR